# TM 11-5538A

DEPARTMENT OF THE ARMY TECHNICAL MANUAL

# RECORDING LIE DETECTOR AN/USS-2C

*DEPARTMENT OF THE ARMY • MARCH 1957*

AGO 5279A—Mar

## WARNING

### DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT

Be careful when working on the 350-volt dc and 275-volt ac plate supply circuits, or on the 115-volt ac line connections.

DON'T TAKE CHANCES!

TECHNICAL MANUAL

# RECORDING LIE DETECTORS AN/USS–2C AND AN/USS–2D

TM 11–5538A
CHANGES No. 1

HEADQUARTERS,
DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C. *30 October 1958*

TM 11–5538A, 28 March 1957, is changed as follows:

The title of the manual is changed as shown above.

*Page 3.* Add the following note below the title of chapter 1:

*Note.* Recording Lie Detector AN/USS–2D is similar to Recording Lie Detector AN/USS–2C. Information in this manual applies to both sets unless otherwise specified.

Change "(fig. 9)" to: (**fig. 9 or 9.1**) in the following places:

*Page 12*, paragraph 20, heading.
*Page 12*, paragraph 21, heading.
*Page 14*, paragraph 22, heading.
*Page 23*, paragraph 41*b*(3), line 3.
*Page 24*, paragraph 45*a*, line 3.

Add "(C model)" to the following captions and paragraph headings:

| Page | Fig. No. | Page | Par. No. |
|---|---|---|---|
| 5 | 2 | 26 | 51 |
| 6 | 3 | 26 | 52 |
| 7 | 5 | 28 | 53 |
| 10 | 7 | 28 | 54 |
| 13 | 9 | 28 | 56 |
| 27 | 16 | 31 | 61*d* |
| 27 | 17 | | |
| 30 | 18 | | |
| 34 | 21 | | |
| 35 | 22 | | |
| 36 | 24 | | |
| 37 | 25 | | |
| 42 | 28 | | |

Change "(fig. 21)" to (**fig. 21 or 21.1**) in the following places:

*Page 23*, paragraph 41*b*(3), line 2.
*Page 33*, paragraph 63*d*, line 2.

*Page 4*, paragraph 6. Delete the chart and substitute:

| Component | Required No. | |
|---|---|---|
| | C model | D model |
| Gsr pen, 7-inch (fig. 8) | 2 | 2 |
| Cardio or pneumo pen, 5-inch (fig. 8) | 3 | 3 |
| Pen starter | 1 | 2 |
| Hand-pump bulb assembly | 1 | 1 |
| Arm cuff assembly | 1 | 1 |
| Wrist cuff assembly | 2 | 1 |
| Pneumograph chest assembly | 1 | 1 |
| Finger electrode assembly | 2 | 2 |
| Tube of electrode jelly | 1 | 1 |
| Inkwell | 2 | 1 |
| 2-ounce bottle of ink | 1 | 1 |
| Rolls of chart paper | 6 | 1 |
| Pen retainer and checking fixture | 1 | 1 |
| Inkwell filler | 1 | 1 |
| Set of taper connectors | 1 | 1 |

Paragraph 7, line 3. After "except," add: (in C model only).

*Page 6.* Delete paragraph 8 and substitute:

## 8. Running Spares

Spares are provided for all normally expendable items as listed below:

| Running spares | C model | D model |
|---|---|---|
| Chart rolls | 5 | 4 |
| Pen, 7-inch | 1 | 1 |
| Pen, 5-inch | 1 | 1 |
| Inkwell | 1 | 0 |
| Pen starter | 1 | 1 |
| Tube, type 5692 | 1 | 0 |
| Tube, type 12AX7 | 1 | 1 |
| Tube, type 6AQ5 | 0 | 1 |
| Tube, type 5651 | 1 | 0 |
| Finger electrode | 1 | 1 |
| Wrist cuff | 1 | 0 |
| Fuse, cartridge type, 3 amp, 250 v | 2 | 5 |
| Fuse, cartridge type, .01 amp, 125 v | 0 | 5 |
| Fuse, cartridge type, 1/200 amp, 125 v | 2 | 0 |
| Lamp, GE type NE–45 | 1 | 0 |

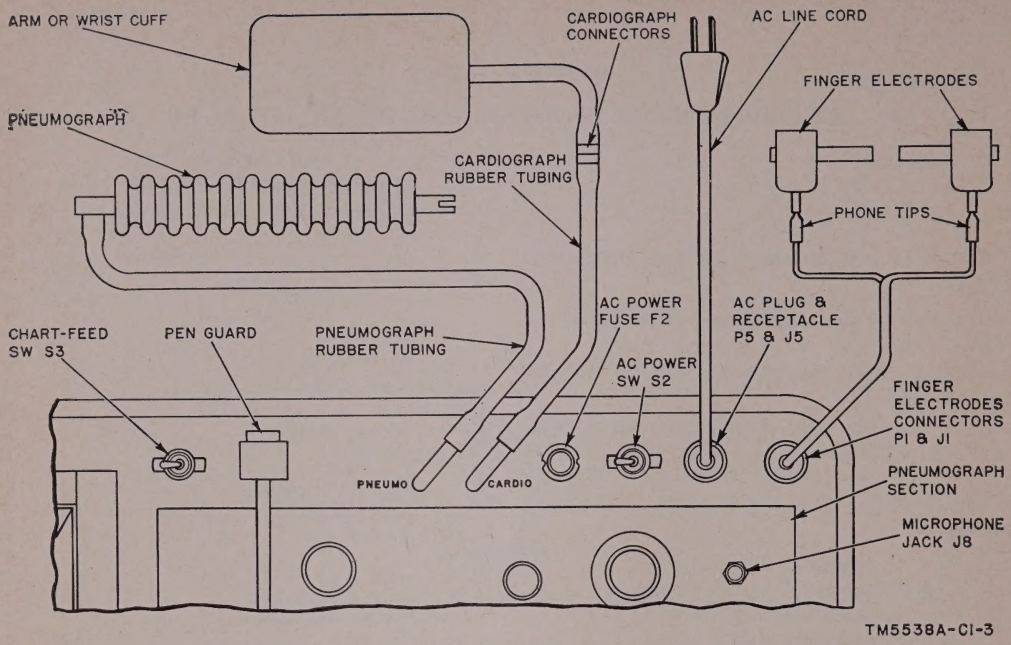



*Figure 7.1* (Added) *Input connections for D model.*

*Page 7*, figure 4. Add the following note:

NOTE:

IN THE D MODEL, THE SLIDE SWITCH IS S4.

## 8.1. Differences in Models

(Added)

The D model differs from the C model in the following details:

*a.* The instrument panel on which all components are mounted is a one-piece panel and is housed in an aluminum suitcase instrument container. Only the lid of the suitcase instrument container is readily removable (pars. 13 and 60).

*b.* All rubber hose, electrode, and power connections have been relocated to the upper right-hand corner of the top panel (fig. 7.1).

*c.* The five sections (pneumograph, gsr recorder, cardiograph, gsr amplifier, and chart feed) are not interchangeable with sections in the C model because a different fastening method is used.

*d.* Modifications have been made in the gsr amplifier section. The FINE centering control has been eliminated because the principal CENTERING control is now a precision 10-turn potentiometer.

*e.* The shifting lever in the chart-feed section has been omitted. A helical clutch spring and the chart-feed switch (fig. 7.1) control movement of the chart paper.

*Note.* The major physical differences between the C and D models may be noted by comparing figures 5, 7, and 9 with figures 7.1 and 9.1.

*Page 9*, paragraph 12*d*, line 5. Change "(1/200 ampere)" to:

**(1/200 ampere in the C model and 1/100 ampere in the D model (fig. 21.1)).**

Paragraph 13*d*, line 4. Change "(fig. 8)" to: **(fig. 8 for C model and fig. 7.1 for D model)**.

Paragraph 14, heading. Change "(figs. 5 and 7)" to: **(figs. 5, 7, and 7.1)**.

*Page 10*, paragraph 15*b*. Change "(fig. 5)" to: **(fig. 5 or 7.1)**.

Paragraph 15*c*, line 1. Change "(fig. 8)" to: **(fig. 8 7.1 for D model)**.

*Page 12*, paragraph 19. Delete the second sentence and substitute:

Figures 9 and 9.1 show the front panels of the C and D model lie detectors respectively.

Paragraph 20. In the "Function" column, delete material opposite "PNEUMO VENT valve," and insert: When the knob is pressed down, prevents operation of the pneumo pen. When the knob is up, permits movement of the pneumo pen.

*Page 14*, paragraph 22. "Control or instrument" column, line 4, after "CENTERING Controls," add: (C model).

Line 6, under "FINE," add: CENTERING control, D model. Opposite this, under "Function" column, add: Adjusts and positions gsr pen tip to zero-reference base on chart paper.

Paragraph 24. In the "Position" column opposite "PNEUMO VENT VALVE," delete "Open (knob in)" and insert: Knob up.

*Page 15*, paragraph 26.

Subparagraph *a*. Change "open (in)" to: **up.**

Subparagraph *c*, line 2. Change "closed (raised)" to: **knob down.**

*Page 16*, paragraph 27.

Subparagraph *c*(3), line 1. After "CENTERING controls" add: on C models.

(3.1) (Added) Adjust the CENTERING control on D models by rotating it until the gsr pen rests on the zero-reference base line on the chart paper.

Subparagraph *d*, line 3. After "control" add: (CENTERING control in D models).

*Page 18*, paragraph 28*e*, Note, line 1. After "setting" add: on the C model.

At the end of the note, add: Do not move the CENTERING control knob rapidly at or near HIGH SENSITIVITY knob settings. The gsr pen will strike forcibly against either stop and become damaged.

Paragraph 29. After subparagraph *b*, add: There is no chart-drive switch lever in the D model.

Delete subparagraph *g* and substitute:

*g*. Set the PNEUMO VENT knob to up and remove the pneumograph chest assembly from the subject.

*Page 23*, paragraph 43. Delete subparagraph *a* and substitute:

*a*. Make sure the PNEUMO VENT knob is in the down position.

*Page 24*, paragraph 45*c*.

Line 3. After "(par. 46)" add: In the D model, remove the amplifier section by running up all eight socket screws 8 turns, lifting up the entire unit, and placing it on top of the panel. In the C model,.

Line 5. After "5651" add: (not used in D model lie detectors).

Line 9. After "amperes" add: In the D model, F1 (fig. 21.1) is rated at 1/100 amperes.

*Page 26*, paragraph 48*a*, line 14. Delete "seals the cardio system airtight" and insert: frees the cardio lever system.

Paragraph 49, line 7. Delete "The PNEUMO VENT valve, which is opened in normal operation, should be closed" and insert: The PNEUMO VENT valve, which is closed (knob up) in normal operation, should be opened (knob down).

Paragraph 50.

Heading. Change "(fig. 16)" to: (**fig. 16 or 16.1**).

Line 12. Change "a a" to: **as a.**

## 51.1. Input Bridge Circuit With Electrodes (D Model)

(figs. 17.1 and 28.1)
(Added)

An arrangement of fixed resistors R2, R6, R7, variable resistor R1, fuse F1 and electrodes (connected to J2) form the four arms of a Wheatstone bridge. Electrode connector J2 is placed opposite the positive voltage supply (+25 volts) within the bridge circuit. The output of the bridge is fed to the chopper circuit through a network formed by resistors R3 and R4 and capacitor C3 (fig. 28.1), to filter out 60-cycle pick-up by the subject. Capacitor C2 and resistors R3, R4, R5, R6, and R2 provide a time-constant circuit when switch S1 is set at AUTOMATIC ZERO. When S1 is set to MANUAL ZERO, C2 is bypassed and the gsr pen will not drift to the reference base line on the chart paper but will remain at the position until readjusted.

*Page 27*, figure 16. Caption. Change "*Grs*" to: **Gsr.**

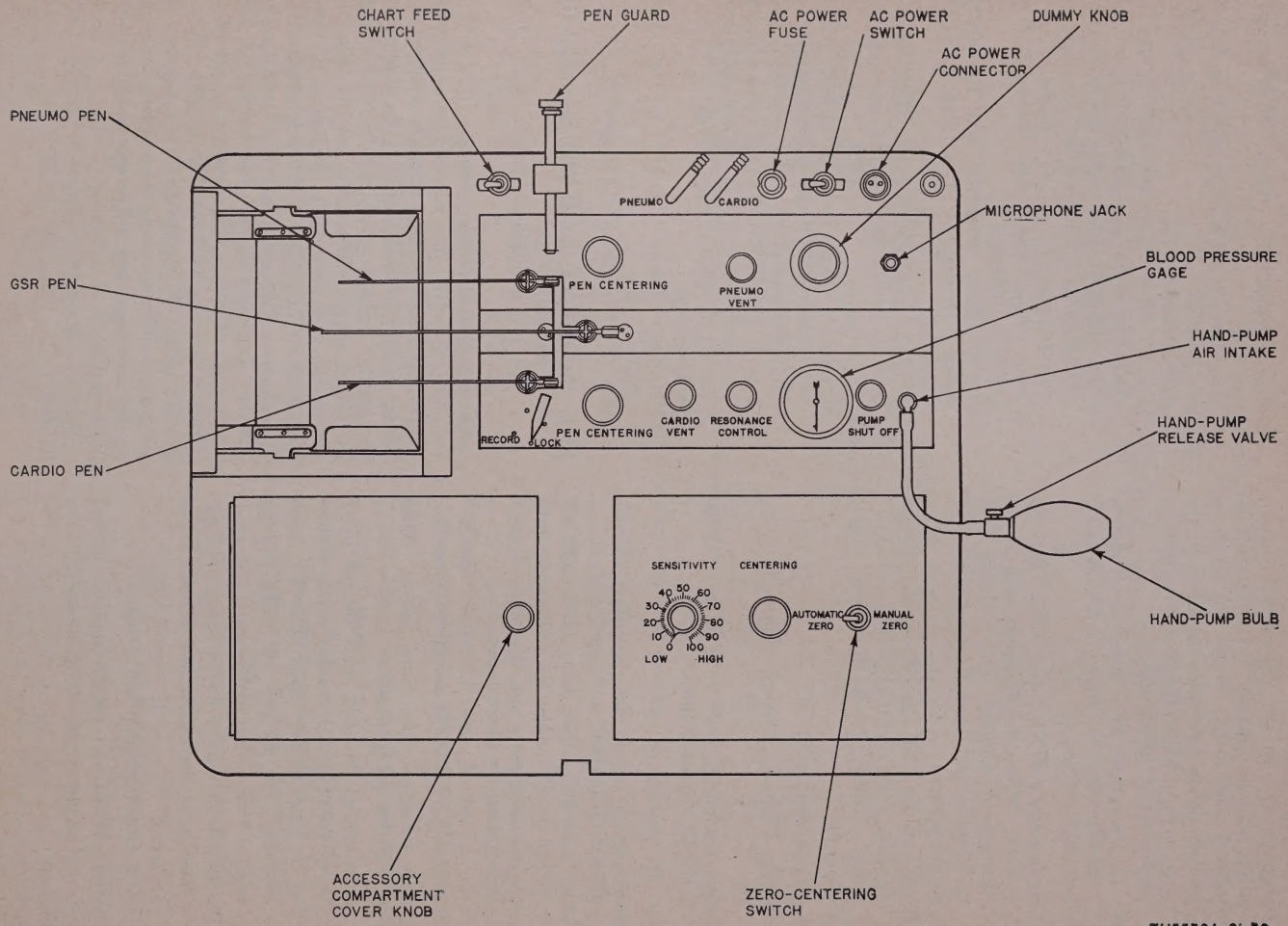



*Figure 9.1* (Added) *Front panel controls and instruments, D model.*

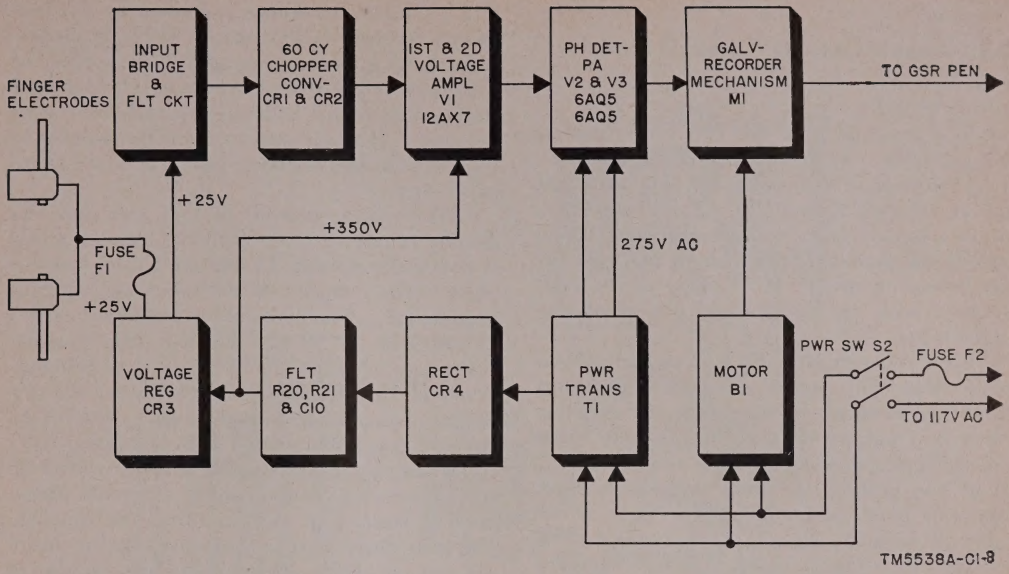



*Figure 16.1* (Added) *Gsr section block diagram, D model.*

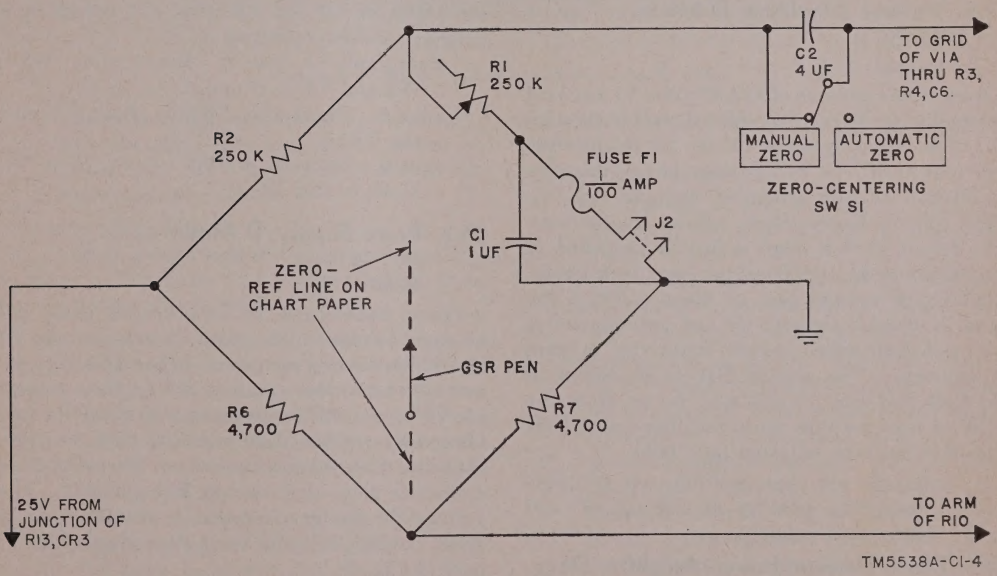



*Figure 17.1* (Added) *Wheatstone bridge, simplified schematic diagram, D model.*

*Page 28.*

## 52.1. Chopper-Converter Circuit, D Model

(fig. 28.1)
(Added)

*a.* The principal parts are two silicon diodes, CR1 and CR2. Approximately 5.8 volts ac from power transformer T1 is fed to the diodes through limiting resistors R8 and R9. The diodes function in a bridge circuit as a 60-cycle single-pole, single-throw shorting switch across the input of first voltage amplifier V1A. This action synchronizes with the conducting phases of the output stage.

*b.* Fixed resistors R11 and R12 and adjustable resistor R10 allow suitable interconnection into the output terminals of the bridge circuit. For bridge zero output (balanced-in position), R10 is screwdriver adjusted for zero output (B, fig. 23) at the grid of the first voltage amplifier. From this point, all amplification occurs at 60 cycles and capacitor C6 will pass only the desired rectilinear wave form to the first voltage-amplifier tube.

Paragraph 53.

## 53.1. Voltage Amplifiers, D Model

(fig. 28.1)
(Added)

Both triode sections of 12AX7 tube V1 are used to amplify the 60-cycle chopped signal fed through C6. The pulsating signal (A, fig. 23) fed into the grid (pin 2) of V1A swings more or less negative in relation to the grounded cathode (pin 3). Plate (pin 1) follows these voltage fluctuations. The output of this stage is further amplified in the second section (V1B) of the same twin triode, providing a voltage gain of about 2,000. The signal is coupled through C7 and potentiometers R18 and R19 which permit sensitivity or gain adjustments. The arm of R19 is connected to the V1B grid (pin 7) and may be set from the LOW or zero position up to maximum or HIGH after R18 has been adjusted (par. 66*b*).

Paragraph 54*b*, line 4 from top of page. Delete "the polarity of this signal" and insert: plate polarity.

## 54.1. Phase Detector-Power Amplifier Stage, D Model

(fig. 28.1)
(Added)

*a.* This stage uses two pentodes, V2 and V3, with grids connected in parallel through C11 and C12. Cathode resistance is formed by the galvanometer coil (1,000 ohms) which is center-tapped and grounded through R25. Screwdriver adjustable resistor R23 compensates for incidental electrical unbalance between the triode connected pentodes. It is adjusted to cause the gsr pen to track on the zero-reference base line of the chart paper strip.

*b.* The plates (pins 5) of both pentodes are directly connected to the high-voltage ac winding of power transformer T1 and are fed in opposite phase. The midpoint of this secondary winding is grounded. When a signal is impressed on the control grids of V2 and V3, the plate polarity determines which of the two tubes will respond. When the input signal to the lie detector (subject's change of resistance) is positive-going referred to balanced condition, only positive-swinging half-cycles are generated by the chopper-converter and appear as such at both grids. The tube whose plate is positive at that moment will conduct. The tube whose plate is negative at that moment will not conduct. This synchronous action is controlled by the power line 60-cycle frequency through T1 acting on the chopper-converter and the plates of V2 and V3 alike, and results in a polarity sensitive operation.

Paragraph 55, line 2. Insert after "V2": (V2 and V3 on D model (fig. 28.1)).

Line 5. Insert after "R30": (R23, D model (fig. 28.1)).

Line 9. Insert after "V2": (tube V2 or V3, D model (fig. 28.1)).

## 56.1. Power Supply, D Model

(fig. 28.1)
(added)

Power transformer T1 furnishes all plate and filament voltages. The plate of each pentode V2 and V3, is directly connected to the 275-volt center-tapped secondary winding of T1. Plate voltage for V1 is rectified by 3-section rectifier CR4 and filtered by resistors R20 and R21 with 3-section capacitor C10. Approximately +350 volts dc is applied to plate load resistors R15 and R16. The voltage for bridge operation is stabilized by a Zener diode, CR3, and feeds the input bridge at point A (fig. 28.1).

*Page 30*, paragraph 60*e*. At the beginning of the subparagraph, add: On C model lie detectors.

At the end of the subparagraph, add: On D model lie detectors, remove any of the five sections by rotating counterclockwise all

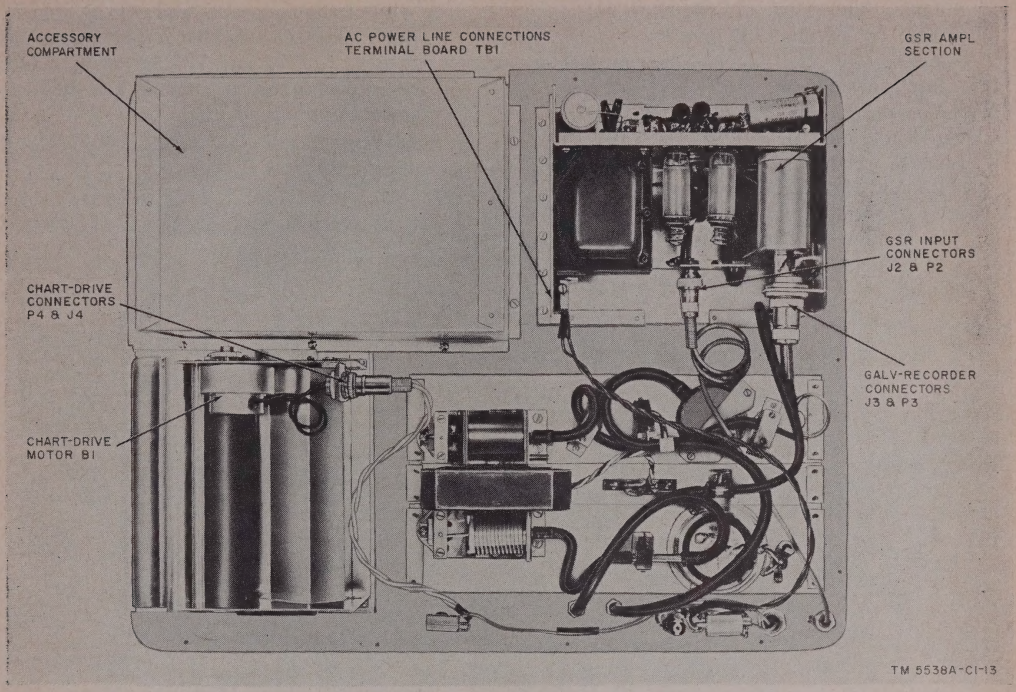



*Figure 18.1* (Added) *Lie detector, bottom view, D model.*

countersunk screws of the unit 8 turns only. Lift the panel into the stepped recess at either end. This frees the other end for total removal.

*Page 31*, paragraph 61.

*e.* (Added) *Replacement of Pneumographic Unit, D Model.* To replace the pneumographic unit, remove the old unit as follows:

(1) Remove all pens and the inkwell.
(2) Rotate all four countersunk screws counterclockwise 8 turns only and lift the panel on one end into the stepped recess. This frees the other end for total removal.
(3) Slip off the interconnecting pneumograph rubber tubing.
(4) When mounting the new unit, follow the above procedures in reverse order. Test for leaks (*a* above) and check the pen travel adjustment (*c* above).

*Page 32*, paragraph 62. Delete subparagraph *d* and substitute:

*d. Replacement of Cardiosphygmographic Unit.* If the cardiosphygmograph section must be replaced, follow the procedure outlined in paragraph 61*d* or *e*.

*Page 33*, paragraph 63.

Subparagraph *b*, line 2 from top of page. After (fig. 28) add: (J6 and J7 (fig. 28.1) for the D model).

Line 8. After "(S3)" add: (S4 in D model).

Subparagraph *c*, lines 2 and 3. After "P2," add: (P3 (fig. 18.1) in D model).

Subparagraph *d*, line 8. After "P2," add: On D models, remove the amplifier section by rotating all countersunk screws counterclockwise 8 turns only. Lift the unit into the stepped recess below upper or lower panel edge. This will free the other edge for total removal. Be careful not to force power, galvanometer, or electrode connecting wires. Temporarily disconnect P3.

Line 11. Change "(figs. 24 and 28)" to: (figs. 24 or 24.1, and 28 or 28.1).

Subparagraph *e*.

Line 2. After "figure 28," add: or figure 28.1 for D model lie detectors.

Subparagraph (1), line 1. After "+21 volts," add: (+25 volts in D models).

Subparagraph (2), line 8. Change "soldering" to: **soldered.**

Subparagraph (3), line 8. After "S3," add: (S4 in D model).

Line 15. After "(fig. 21)," add: (R10 (fig. 21.1) in D model).

Subparagraph *f*, line 6. After "V2," add: on C models; pins 2 of tubes V2 and V3 in D model. Also change "F" to: **E** in C model.

At end of subparagraph, add: On D models, the V1 voltage amplifier output is applied to pins 2 of V2 and V3 (fig. 28.1). Only one of the tubes can conduct and pass the signal of proper polarity.

Subparagraph *g*, lines 2 and 3. After "CR3," add: (CR4 in D model).

Line 3. After "C8," add: (C10 in D model).

Subparagraph *h*, lines 6 and 8. After "J2," add: (J3 in D model).

*Page 34.*

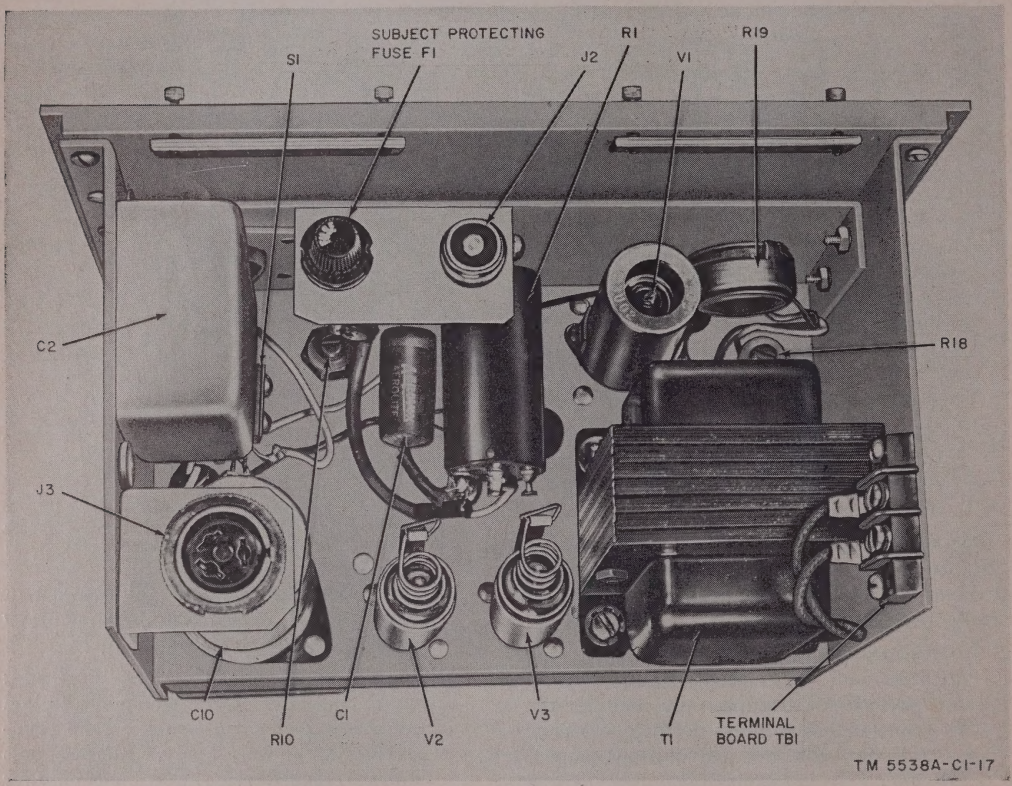



*Figure 21.1* (Added) *Gsr amplifier top, parts location, D model.*

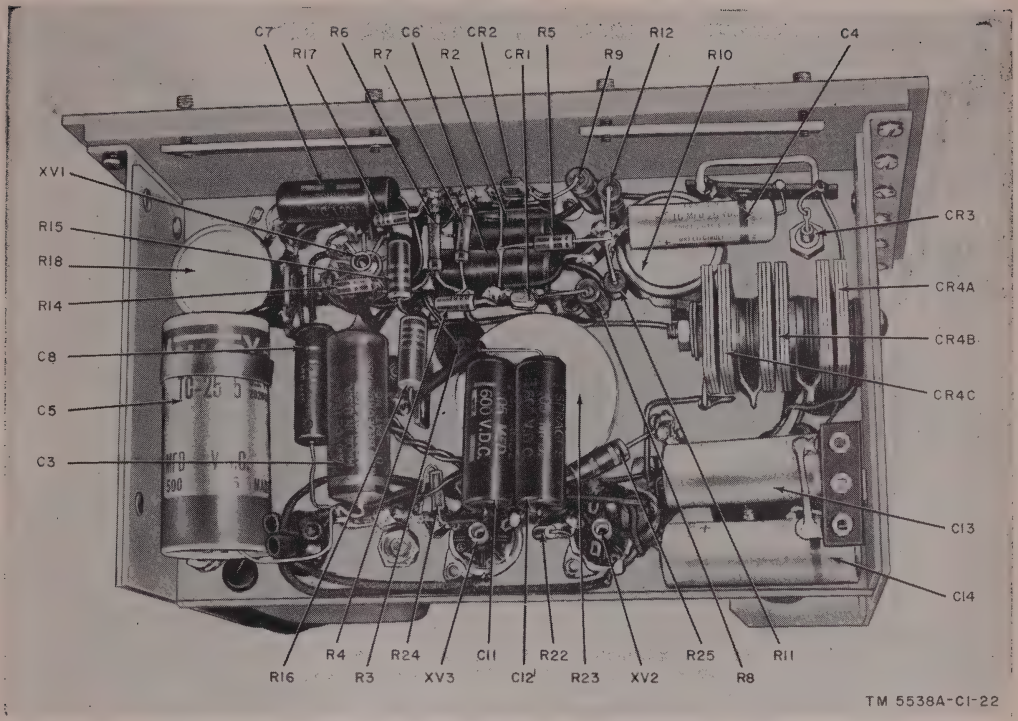
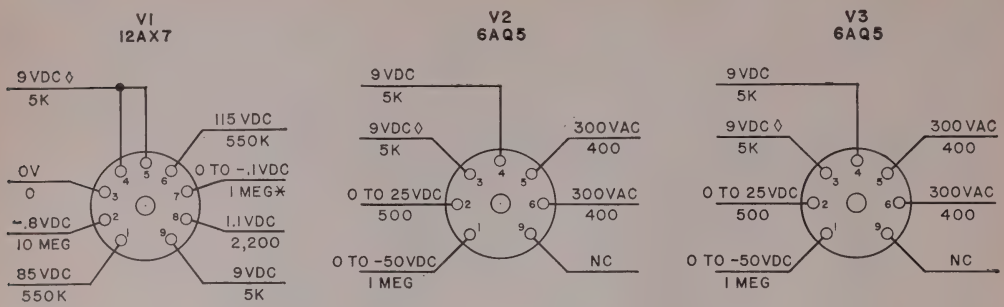



*Figure 22.1* (Added) *Gsr amplifier bottom, parts location, D model.*




NOTES:

1. ALL MEASUREMENTS TAKEN AFTER BALANCING-IN PROCEDURE AGAINST CHECKING FIXTURE.
2. VOLTAGES MEASURED BETWEEN TUBE PIN & GROUND.
3. MEASUREMENTS TAKEN WITH VTVM.
4. RES READING BELOW LINE, VOLT READING ABOVE.
5. * SENSITIVITY CONTROL SET AT HIGH.
6. ◊ 6.3V AC TO PIN 9 OF V1.

TM5538A-CI-5

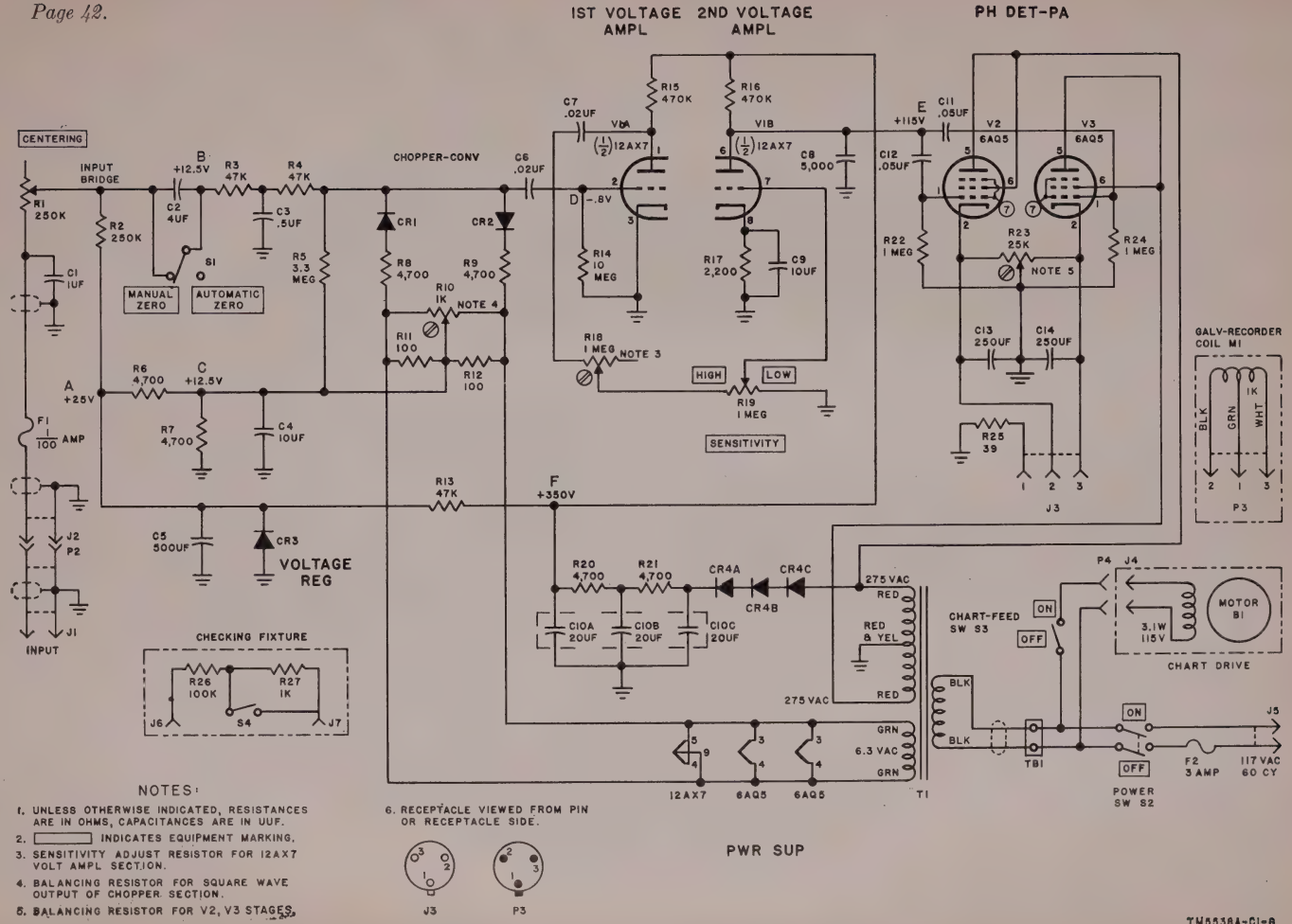
*Figure 24.1* (Added) *Voltage and resistance measurement chart, D model.*

Paragraph 65, line 3. Change "If" to: If, on C model lie detectors,.

At end of paragraph, add: On D model lie detectors, this adjustment is factory-set and fixed. At times, the pen cradle may have been forced from the fixed position on its shaft by whipping. To correct this defect, loosen the screw at the collar, reset for even pen travel over the chart strip to either limit, and tighten this screw.

Paragraph 66*b*, line 3. After "(fig. 28)," add: (R18 (fig. 28.1) in D models).

Paragraph 67*a*, last line. After "(fig. 18)," add: (P4, in D model (fig. 18.1)).




NOTES:

1. UNLESS OTHERWISE INDICATED, RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UUF.
2. ▭ INDICATES EQUIPMENT MARKING.
3. SENSITIVITY ADJUST RESISTOR FOR 12AX7 VOLT AMPL SECTION.
4. BALANCING RESISTOR FOR SQUARE WAVE OUTPUT OF CHOPPER SECTION.
5. BALANCING RESISTOR FOR V2, V3 STAGES.
6. RECEPTACLE VIEWED FROM PIN OR RECEPTACLE SIDE.

TM5536A-C1-8

*Figure 28.1* (Added) *Main schematic diagram, model D.*

[AG 413.6 (22 Oct 58)]

By Order of *Wilber M. Brucker*, Secretary of the Army:

MAXWELL D. TAYLOR,
*General, United States Army,*
*Chief of Staff.*

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Ports of Emb (OS) (2)
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Army Terminals (2)
OS Sup Agcy (2)
Yuma Test Sta (2)
USA Elct PG (1)
Sig Lab (5)
Sig Fld Maint Shops (3)
Fld Comd, AFSWP (5)
Mil Dist (1)
Sector Comd, US Army Corps (Res) (1)
US Army Corps (Res) (1)
JBUSMC (2)
Units organized under following TOE's:
11–587 (2)
11–592 (2)
11–597 (2)
19–500 (AA–AE) (2)
30–15 (2)
30–17 (2)
30–18 (2)
30–19 (2)
30–22 (2)

*NG:* State AG (3); units—same as Active Army except allowance is one copy to each unit.
*USAR:* None.
For explanation of abbreviations used, see AR 320–50.



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TECHNICAL MANUAL
No. 11–5538A

DEPARTMENT OF THE ARMY
WASHINGTON 25, D. C., *28 March 1957*

# RECORDING LIE DETECTOR AN/USS–2C


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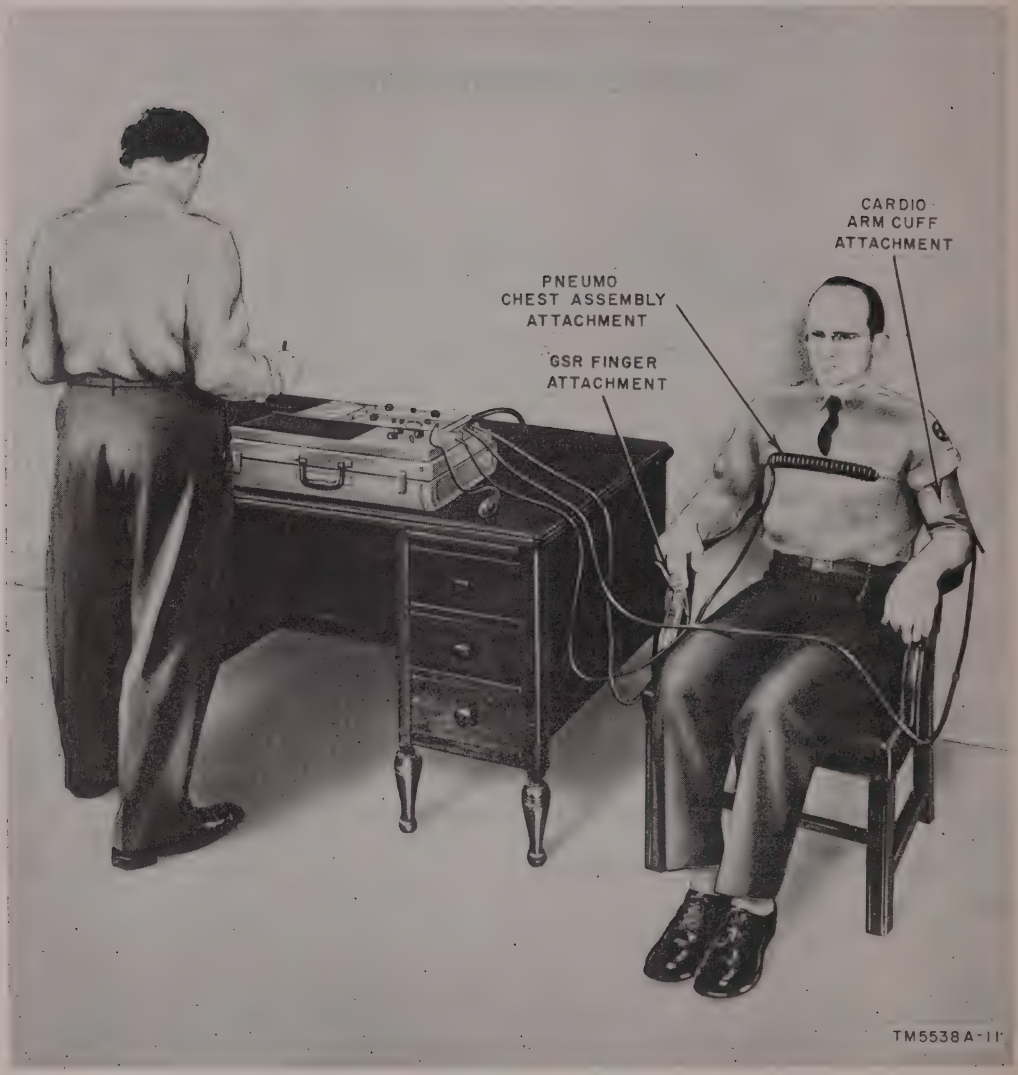


*Figure 1. Recording Lie Detector AN/USS–2C.*

# CHAPTER 1
# INTRODUCTION

## Section I. GENERAL

### 1. Scope

*a.* This manual contains instructions for the installation, operation, maintenance, and repair of Recording Lie Detector AN/USS–2C (fig. 1).

*b.* Forward comments on this publication directly to Commanding Officer, United States Army Signal Publications Agency, Fort Monmouth, N. J.

### 2. Forms and Records

*a. Unsatisfactory Equipment Reports.* Fill out and forward DA Form 468 (Unsatisfactory Equipment Report), to Commanding Officer, U. S. Army Signal Equipment Support Agency, Fort Monmouth, N. J., as prescribed in AR 700–38.

*b. Damaged or Improper Shipment.* Fill out and forward DD Form 6 (Report of Damaged or Improper Shipment), as prescribed in AR 700–58 (Army).

*c. Preventive Maintenance Forms.*

(1) Prepare DA Form 11–238, (Operator First Echelon Maintenance Checklist for Signal Corps Equipment) (Radio Communication, Direction Finding, Carrier, Radar) (fig. 12), in accordance with instructions on the back of the form.

(2) Prepare DA Form 11–239 (Second and Third Echelon Maintenance Checklist for Signal Corps Equipment) (Radio Communication, Direction Finding, Carrier, Radar) (fig. 13), in accordance with instructions on the back of the form.

### 3. Common Names

The common names for Recording Lie Detector AN/USS–2C and its three associated testing sections are listed below—

| Nomenclature or test section | Common name |
|---|---|
| Recording Lie Detector AN/USS–2C. | Lie detector |
| Cardiosphygmographic section | Blood pressure, Cardio, or cardiograph. |
| Pneumographic section | Pneumo or pneumograph. |
| Galvanic skin resistance amplifier section. | Gsr |

## Section II. DESCRIPTION AND DATA

### 4. Purpose and Use

*a.* Recording Lie Detector AN/USS–2C (fig. 1) is a transportable test unit that indicates a subject's inner reactions to questioning.

*b.* The equipment detects changes in relative blood pressure (cardio section), respiration cycles (pneumo section), and skin resistance (gsr section) when these reactions occur under questioning. The indicated changes are shown by recorded traces (fig. 10). Provisions are also made in the lie detector for furnishing an audio-frequency (af) signal to auxiliary of equipment (par. 10).

### 5. Technical Characteristics

*a. Cardiograph Section.*

Maximum pressure permissible within system as read on gage ..... 150-mm Hg.
Sensitivity at pen point at change from 90- to 92-mm Hg pressure ..... Approximately ¾ inch displacement.

| | |
|---|---|
| Maximum frequency response to obtain 75 percent pen excursion | Approximately 5 cps. |
| Permissible air leakage at 90-mm Hg pressure within 15-minute intervals. | ¼ inch at pen point. |

*b. Gsr Section.*

| | |
|---|---|
| Amplification factor of amplifier | 5,600. |
| Response time factor of balance restoring circuit in automatic zero position. | Approximately 5 seconds. |
| Resistance coverage between electrode terminals | Approximately 1,000 to 250,000 ohms. |
| Output impedance | 1,000 ohms. |
| Sensitivity control of pen response | Pen excursion with a change from 100,000 to 99,000 ohms between finger electrodes at high sensitivity setting is 1 inch. |
| Power output of amplifier | 2 watt. |
| Galvanometer current for zero-reference position | 14 ma. |
| Frequency response | 0 to 10 cps for normal operating range. |
| Input voltage | 115 volts at 60 cps. |

*c. Pneumograph Section.*

| | |
|---|---|
| Maximum sensitivity at pen point with change from 0 to 2 mm | ¼ inch. |
| Maximum frequency response to obtain 75 percent pen excursion | Approximately 5 cps. |
| Permissible air leakage within 2 minutes | 1 inch at pen point. |

*d. Chart-Drive Mechanism.*

| | |
|---|---|
| Speed of paper | 6 inches per minute. |
| Voltage source for electric drive | 115 volts 60 cycles. |
| Synchronous motor | 5 rpm, 3 watts. |
| Paper width | 6 inches. |
| Paper length | Approximately 100 feet per roll. |

*e. Microphone.*

| | |
|---|---|
| Impedance | 5 megohms. |
| Frequency range | 50 to 10,000 cps. |
| Output | 51 db below 1 volt per microbar. |

## 6. Table of Components

(fig. 2)

The lie detector is equipped with the following minor components. The minor components are located in the accessory compartment (fig. 3).

| Component | Required No. |
|---|---|
| Gsr pen, 7-inch (fig. 8) | 2 |
| Cardio or pneumo pen, 5-inch (fig. 8) | 3 |
| Pen starter | 1 |
| Hand-pump bulb assembly | 1 |
| Arm cuff assembly | 1 |
| Wrist cuff assembly | 2 |
| Pneumograph chest assembly | 1 |
| Finger electrode assembly | 2 |
| Tube of electrode jelly | 1 |
| Inkwell | 2 |
| 2-ounce bottle of ink | 1 |
| Rolls of chart paper | 6 |
| Pen retainer and checking fixture | 1 |

## 7. Description

(figs. 2 and 3)

The lie detector is inclosed in a luggage-type case (fig. 6). All of the operating controls are located on the front panel except the alternating-current (ac) power switch (fig. 5). The minor operating components and running spares (par. 8) are stored in the accessory compartment. The microphone is concealed behind a dummy knob on the front panel. The main operating accessories are—

*a. Pneumograph Chest Assembly.* The pneumograph is a black rubber, bellows-type tubing about 11 inches long. A 40-inch length of beaded chain and a 6-foot rubber hose are fixed to one end of the pneumograph. The other end of the rubber hose is equipped with a tapered fitting.

*b. Cardiograph of Blood Pressure Cuff Assembly.* Each cuff consists of a cloth bandage that contains a latex rubber bag. Two rubber hose

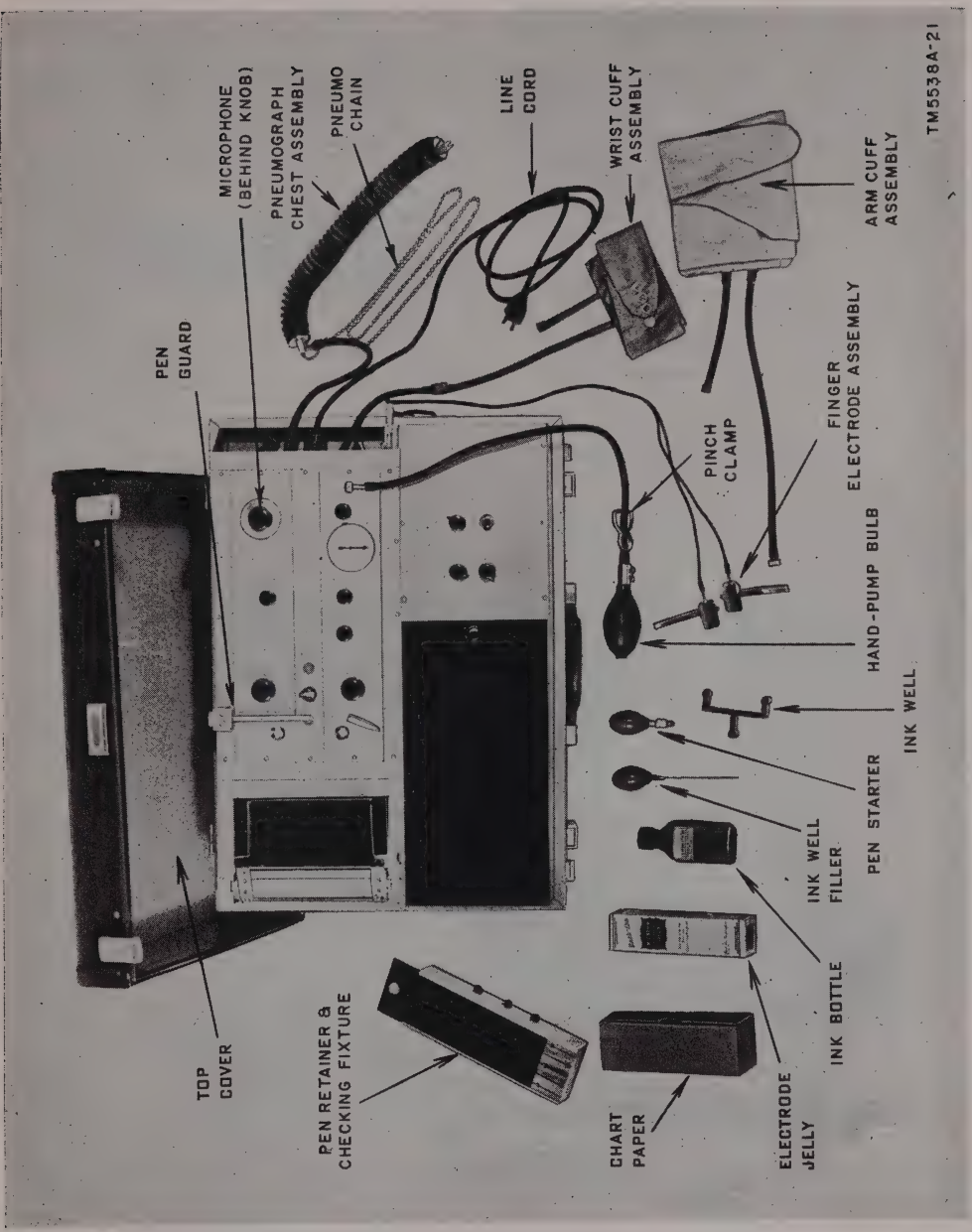


*Figure 2. Lie detector, components.*

stubs connect to each rubber bag. One stub is sealed off; the other has a tapered fitting. The arm cuff wraps around the arm (fig. 1). The wrist cuff goes around the wrist and has snap fasteners on each end.

*c. Hand-Pump Bulb Assembly.* The hand-pump bulb assembly consists of a rubber bulb, a release valve operated by a knurled head screw (fig. 15), and a short length of rubber hose. A pinch-type clamp is also provided as a shut-off device.

*d. Finger Electrode Assembly.* The finger electrode assembly (figs. 7 and 11) consists of two narrow stainless-steel strips equipped with band-like retainer. This pair is attached to a shielded electrical cord by telephone tips and terminated at the other end by a screw-connector fitting.

*e. Pens* (fig. 8). The pens for the pneumographic, cardiosphymographic, and galvanometer assemblies are hollow, stainless-steel tubes. The grs pen is 7 inches long and the cardio and pneumo pens are 5 inches long.

*f. Pen Retainer and Checking Fixture* (fig. 4). The pen retainer and checking fixture is a two-section rectangular box and is stored in the accessory compartment. The top section is used to store the pens which are protected by a sliding cover. The lower section is provided with a pair of jacks and a dummy-test slide switch and is used as substitute for a subject during the final checking and testing procedures.

*g. Pen Starter.* The pen starter consists of a small rubber bulb with a plastic insert.

## 8. Running Spares

Spares are provided for all normally expendable items as listed below:

5 chart rolls
1 pen, 7 inches long
1 pen, 5 inches long
1 inkwell

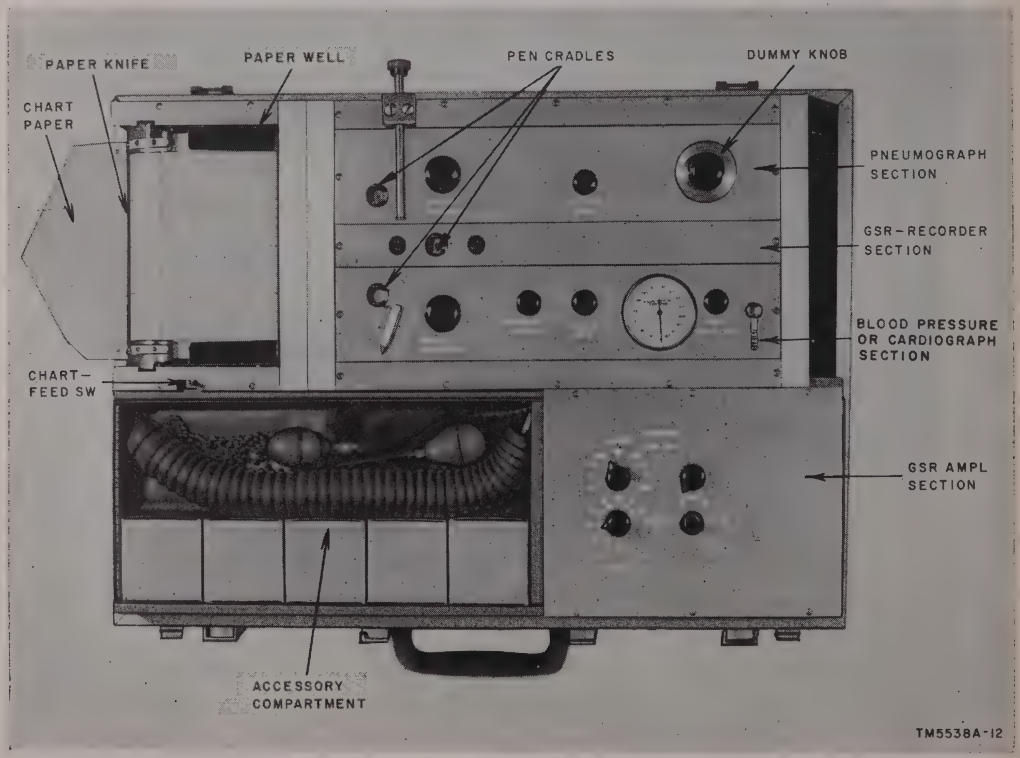


*Figure 3. Lie detector with accessory compartment cover removed, top view.*

1 pen starter
1 tube type—5692
1 tube type—12AX7
1 tube type—5651
1 wrist cuff
1 finger electrode
2 fuses, 3 amp

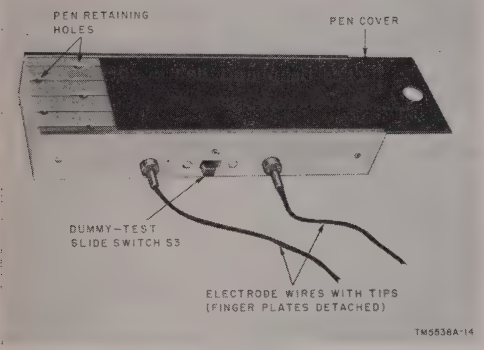


*Figure 4. Pen retainer and checking fixture.*

2 fuses, 1/200 amp
1 power indicator light

## 9. Additional Materials Required but Not Supplied

A bottle of denatured alcohol and a quantity of surgical cotton is required when the gsr section is to be used. Refer to paragraph 27*a*(1) for their uses.

***Warning:*** Mark the bottle as follows: POI-POISON—FOR EXTERNAL APPLICATION ONLY.

## 10. Auxiliary Equipment

When the microphone is to be used, the following auxiliary equipment is required:

*a.* A tape or wire recorder for keeping a semi-permanent or permanent record.

*b.* An audio amplifier with a headset or loudspeaker for concurrent listening.

*c.* When either the recorder or audio amplifier is used, a cord containing a male plug such as Plug PL–55 is required for connection to the microphone jack (fig. 5).

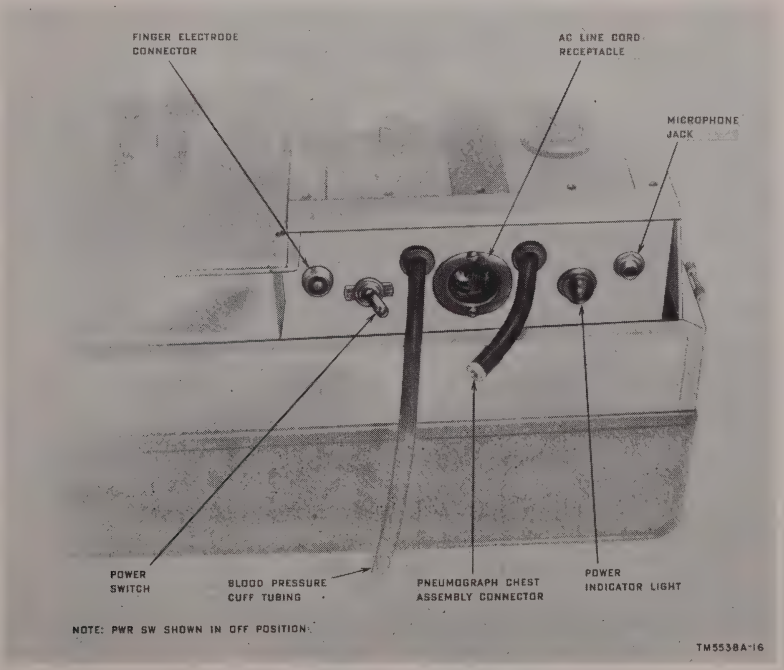


*Figure 5. Lie detector, side panel view.*

# CHAPTER 2
# INSTALLATION

## Section I. SERVICE UPON RECEIPT OF LIE DETECTOR

### 11. Unpacking
(fig. 6)

*a. Packaging Data.* When packed for shipment, the lie detector is put into moisture-and vapor-proof cartons and placed in a single wooden box. The box is 29 inches long, 23 inches wide, 16 inches deep and has a volume of 6.2 cubic feet. It weighs 96 pounds.

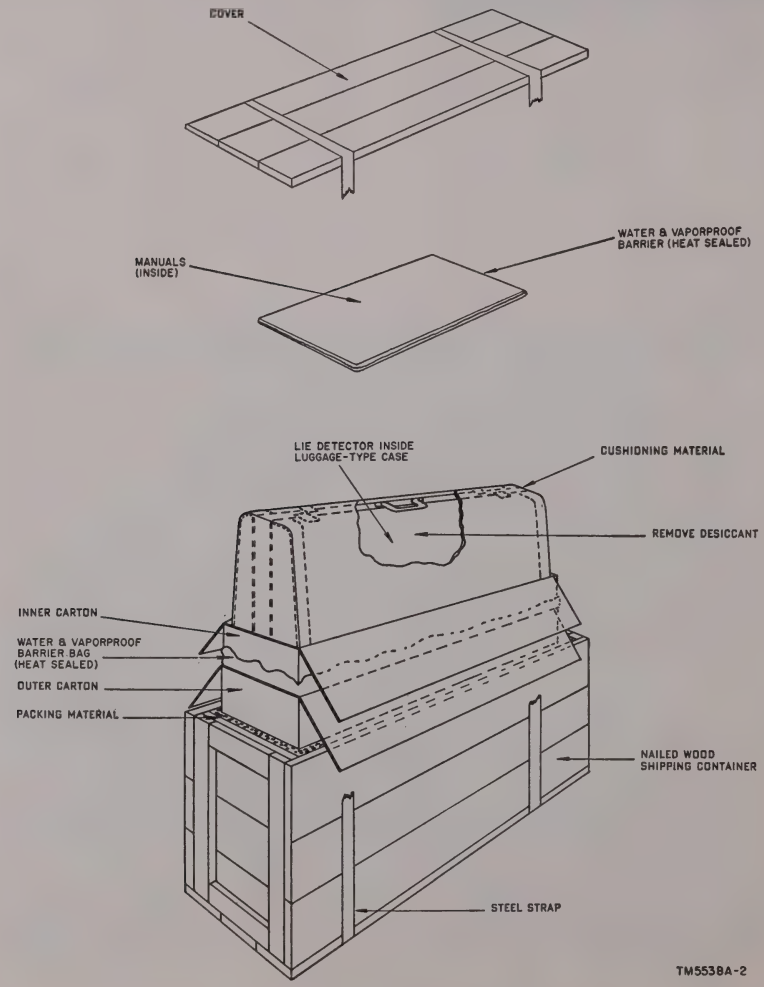


*Figure 6. Typical packaging diagram.*

*b. Removing Contents.*

(1) Cut and fold back the steel straps.

(2) Remove the nails from the top of the box with a nail puller. Remove the top. Do not attempt to pry it off because the equipment may become damaged.

(3) Remove the top layer of packing material and lift out the outer carton.

(4) Open the top of the outer carton and lift out the inner carton wrapped in the water and vapor barrier bag.

(5) Open the bag and remove the inner carton.

(6) Open the inner carton and remove the cushioning material and desiccant that protects the case of the lie detector and the small package containing the manuals.

(7) Remove the lie detector from the carton.

(8) Remove the water and vapor barrier bag that protects the manuals and place the manuals on the test bench.

### 12. Checking Unpacked Lie Detector

*a.* Inspect the equipment for damage incurred during shipment. If the equipment has been damaged, refer to paragraph 2.

*b.* See that the lie detector is complete as listed on the packing slip. If a packing slip is not available check it against figure 2, the table of components in paragraph 6, and the list of running spares in paragraph 8.

*c.* If the lie detector has been used or reconditioned, see whether it has been changed by a Modification Work Order (MWO). If modified, the MWO number will appear on the front panel. Check to see that this MWO number also appears on the schematic diagram of the manual accompanying the equipment. If not, add a note to the overall schematic diagram.

*d.* Remove the bottom cover of the lie detector (fig. 18) to check the gsr amplifier tubes (fig. 21). Check the subject-protecting fuse (fig. 21) and be sure that it is rated at its proper value (1/200 ampere).

*Note.* The ac power fuse is on the front panel and is rated at 3 amperes. Do not confuse this fuse with the subject-protecting fuse.

## Section II. INSTALLATION

### 13. Installation of Lie Detector

*a.* A quiet, plainly furnished, medium-sized room with soft-colored walls provides the best place to set up the equipment. Whenever possible, avoid locations where outside noises would be annoying. Remove wall ornaments, unless they conceal an opening used by persons outside the room to watch, listen, or record the tests. Do not use glaring lights. Make the subject as comfortable as possible.

*b.* Place the lie detector on a large table where working papers, records, and accessories can be easily accommodated. Allow enough room at either side of the lie detector for the free run of the recording chart paper to the left of the equipment, and distribution of the cardio and pneumo rubber tubing and finger electrode cables to the right (fig. 1). Provide chairs for the examiner (operator) and the subject.

*c.* Open the cover of the accessory compartment. Remove either the arm or the wrist cuff (as preferred), the pneumograph with tubing, finger electrodes with cord and connector, line cord, and a roll of chart paper.

*d.* Raise the writing table (fig. 14) enough to allow a roll of chart paper to be placed into the paper well (figs. 14 and 3). Set the chart-drive switch to the right-hand position (off) (fig. 8). Pull the free end of the chart paper through the paper guide rails. The perforations near the edges of the paper should engage the sprocket pins. Pull the free end of the paper between the knife and out a few inches past the knife. Figure 3 shows how the chart paper should look when properly installed.

### 14. Connections

(figs. 5 and 7)

***Caution:*** Set the ac power switch to OFF before making any connections.

*a. Arm or Wrist (Blood Pressure) Cuff Assembly.* Attach the rubber hose with the tapered fitting (long hose) to the (cardiograph) cuff tubing connector.

*b. Pneumograph Chest Assembly.* Attach the tapered end of the rubber hose of the pneumograph tubing to the pneumograph chest assembly connector.

*c. Hand-Pump Bulb.* Attach the rubber hose of the hand-pump bulb (fig. 2) to the hand-pump connector.

*d. Finger Electrodes.* Attach the screw-type connector on the finger electrode cord to the connector on the lie detector and screw it down tightly.

*e. Power Cord.* Plug the female connector of the power cord into the ac line receptacle with a slight twist to lock it and insert the other end into a 115-volt ac convenience outlet.

## 15. Checking Chart-Drive Mechanism

*a.* Set the controls as listed in the table given in paragraph 24.

*b.* Turn the power switch (fig. 5) to ON.

*c.* Shift the chart-feed switch (fig. 8) to the left (on position).

*d.* The chart paper should advance at the rate of 6 inches per minute.

## 16. Filling Inkwell and Installing Pens

*a.* Remove the inkwell, ink bottle, pen retainer and checking fixture, and the ink filler from the accessory compartment.

*b.* Move the pen guard out of the way as follows:

(1) Unscrew the knurled head nut of the pen guard (fig. 3).

(2) Pull the rod out (fig. 8) so that the inkwell and the pneumo pen can be put in their operating positions.

*c.* Place the inkwell inside the pen cradles (fig. 3); use the locating pins to obtain the correct seating. Figure 8 shows the proper installation of the inkwell.

*d.* Slide back the cover of the pen retainer and checking fixture (fig. 4) and remove the two short (5-inch) pens and one long (7-inch) pen (fig. 8).

***Caution:*** The pens are delicate instruments. Be careful when removing, handling, and installing the pens into their cradles.

*e.* Place each pen gently into its respective cradle (fig. 8); use the horizontal locating pins

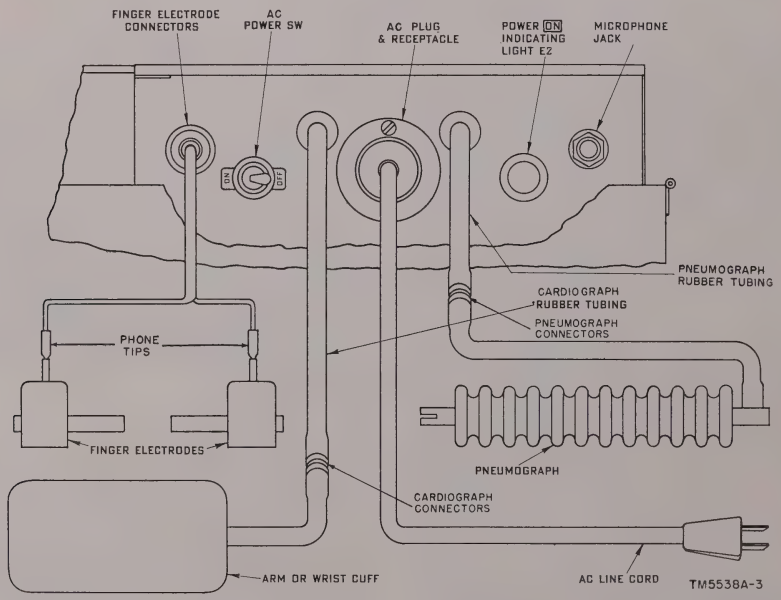


*Figure 7. Side panel connections.*

on the rear of the pens as a guide. The pens are correctly installed when they can be rocked in their cradles, the rear tips of the pens are dipped in the ink cups, and the writing tips rest on the chart paper (par. 18).

## 17. Priming Recording Pens

*a.* Remove the pen starter from the accessory compartment.

*b.* Squeeze the bulb of the pen starter gently and insert the writing tip of one of the pens into the small hole in the pen starter (fig. 8). A shallow groove in the pen starter will guide the pen tip into the hole.

*c.* Release the slightly compressed bulb and watch for the ink flow to appear through the transparent starter tip. When it does show, withdraw the pen starter and allow the pen to rest on the chart paper.

*d.* Feed a short length of chart paper (par. 15) to see that this pen has been primed satisfactorily. If it does not write or stops writing during this short run, air may have been drawn in. Repeat this priming procedure.

*e.* Repeat the priming procedure in *a* through *d* above for the other two pens.

## 18. Pen Counterweight Adjustment

Some inks may upset the delicate balance of the pen because they vary in metallic content. The lightest touch of the pen on the chart paper consistent with continuous writing is necessary. Adjust the hexagonal counterweight (fig. 8) in or out as required to produce the proper pen touch with minimum friction on the chart paper.

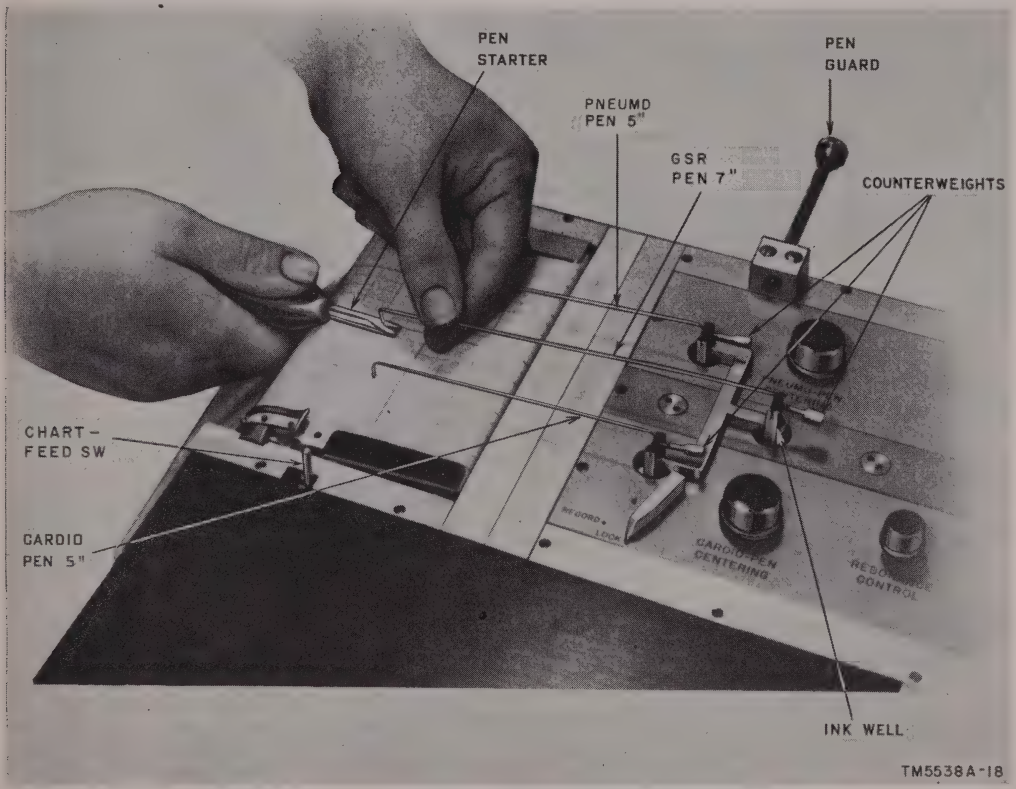


*Figure 8. Priming recording pens.*

# CHAPTER 3
# OPERATION

## Section I. CONTROLS AND INSTRUMENTS

### 19. General

The operator (examiner) must become thoroughly familiar with the controls and instruments of the lie detector. Figure 9 shows the front panel of the equipment with all of the controls. Paragraphs 20 through 22 contain tables describing the principal units, their controls, and functions. Figure 15 shows the mechanical operation of the lie detector.

### 20. Pneumograph Unit Controls (fig. 9)

| Control or instrument | Function |
|---|---|
| Pneumograph chest assembly attachment | Contracts and expands with subject's breathing. |
| Pneumo pen | Shows breathing cycle fluctuations as recorded traces on chart paper (A, fig. 10). |
| PNEUMO VENT valve | When closed (knob out), prevents operation of pneumo pen. |
| | When open (knob in), permits movement of pen. |
| PNEUMO-PEN CENTERING control | Positions pneumo pen writing tip to a zero-reference base line on chart paper. |
| Pen guard | Prevents closing of top cover of lie detector when pens are in operating position. |
| Dummy knob | Conceals microphone. |

### 21. Cardiograph Unit Controls and Hand-Pump Bulb Unit (fig. 9)

| Control or instrument | Function |
|---|---|
| Arm or wrist cuff attachment | Transmits blood-pressure and pulse rate changes from subject to lie detector. |
| Cardio pen | Shows blood-pressure and pulse rate changes as recorded traces on chart paper (C, fig. 10). |
| RESONANCE CONTROL | Increases (knob out) or decreases (knob in) range of cardio pen swing. |
| PUMP SHUT OFF valve | When opened (knob out), permits inflation of cuffs by hand-pump bulb. |
| | When closed (knob in), permits normal operation of cardio pen. |
| CARDIO VENT valve | When closed (knob turned out), seals air in lie detector during test period. |
| | When opened (knob pressed in), gives fast air pressure release after test period. |
| CARDIO-PEN CENTERING control | Positions cardio pen writing tip to a zero-reference base line on chart paper. |
| LOCK RECORD switch: | |
| RECORD position | Permits normal swing of cardio pen. |
| LOCK position | Prevents movement (whipping) of pen during inflation procedure of cuffs. |
| Blood-pressure gage | Indicates proper inflation pressure of cuff attachment. Gage indicates pressure measured in millimeters (mm) of mercury (Hg). Scale markings are in divisions of 20, ranging from 0 to 300. |
| Hand-pump bulb | When pumped, builds up pressure in cuff attachment. |
| Hand-pump release valve | When opened (knob turned to left), releases air from cuff. |
| Pinch clamp (fig. 2) | When opened (press to open), permits inflation of cuffs. |
| | When closed, prevents air leakage from hand-pump bulb opening. |

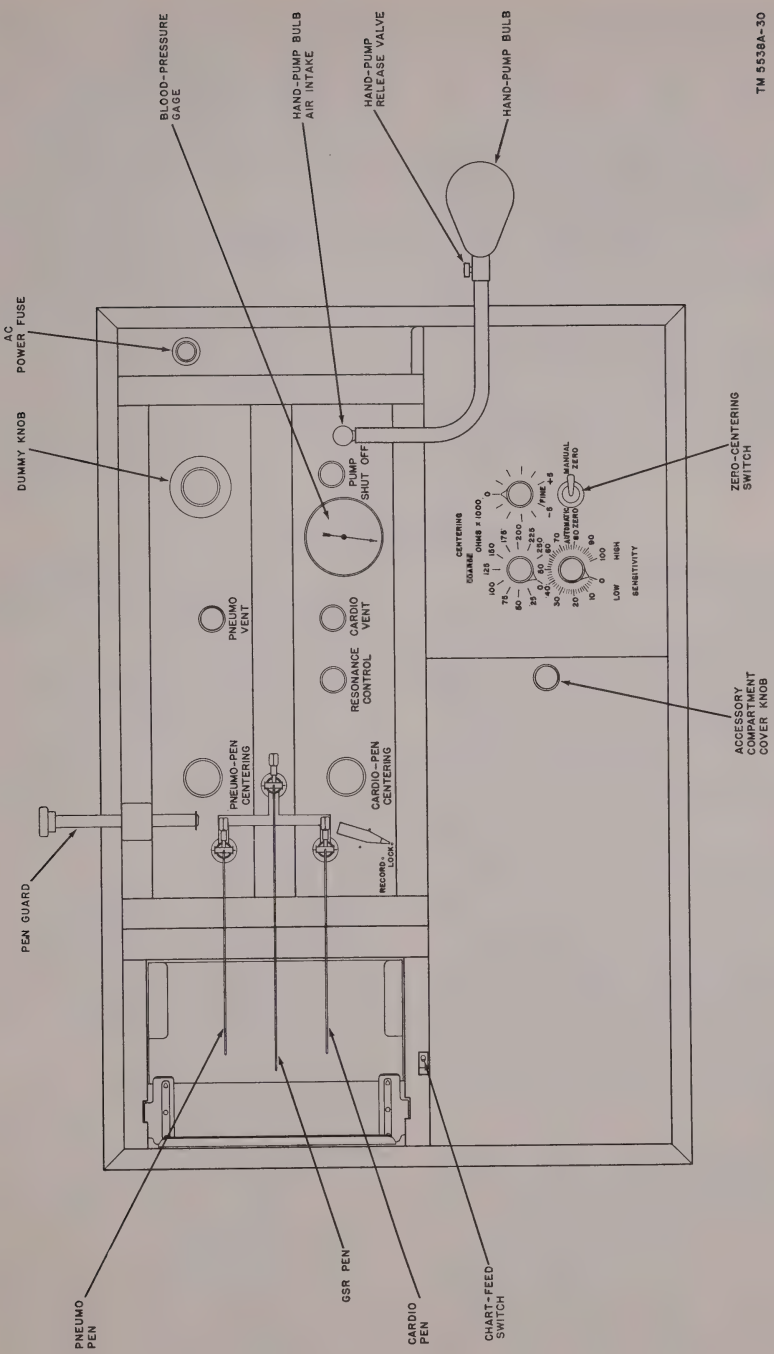


*Figure 9. Front panel controls and instruments.*

## 22. Gsr Section Controls (fig. 9)

| Control or instrument | Function |
|---|---|
| Finger electrode attachments | Transmits changes in skin resistance of subject's fingers to lie detector. |
| Gsr pen | Shows changes in resistance as recorded traces on chart paper (B, fig. 10). |
| CENTERING controls: | |
| COARSE | Adjusts gsr pen writing tip close to zero-reference base line on chart paper. |
| FINE | Positions gsr pen exactly to base line. |
| Zero-centering switch: | |
| AUTOMATIC ZERO position | Gsr pen remains in path above zero-reference base line during test. |
| MANUAL ZERO position | Pen returns to zero-reference base line after subject's reaction impulse. |
| SENSITIVITY control | Permits maximum swing of gsr pen when placed at HIGH. Permits minimum swing of pen when placed at LOW. |
| Power switch (fig. 5) | When set in the ON position (lever to left), turns on gsr section and used in conjunction with chart-drive switch to turn on chart-drive mechanism. |
| Panel indicator light | Indicates power is applied to lie detector. |
| Chart-feed switch | Turns on (lever to left) chart-drive mechanism after power switch has been set to ON. |

# Section II. OPERATION

## 23. Operating Instructions

*a.* To determine the presence or absence of deception by a subject when answering a series of questions, three independent physical characteristics are measured simultaneously and recorded on a moving paper chart; pulse rate and relative blood pressure (cardiograph section), galvanic skin reflex (changes in skin resistance) (gsr section), and respiration cycles (pneumograph section). Figure 10 shows a typical recording. Each tracing is made by a recording pen moving in accordance with the apparatus which is applied to the subject as shown in figure 1. The lie detector contains three corresponding sections, each of which operates one of the pens. Preliminary adjustments are necessary to condition the subject so that an accurate recording of his reactions may be made. The adjustments of the three sections (cardiograph, blood pressure, pneumograph, and gsr) are described in paragraphs 24 through 27 and the overall operational procedure is given in paragraph 28.

*b.* Before starting to test a subject, be sure that the installation procedure (pars. 13–18) has been made. Be ready to start the test as soon as the subject enters the room; needless delays will make him uneasy, possibly resulting in a false record. Before the subject is tested have him wash his hands to remove any substance that might interfere with good contact by the finger electrodes. Have him remove any bulky clothing which would interfere with the recording of his chest expansion. Seat him comfortably in a chair in the examination room.

*Note.* Keep out visitors during the test procedure.

## 24. Preliminary Starting Procedure

Set the controls (fig. 9) as follows:

| Control | Position |
|---|---|
| Power switch (fig. 5) | OFF |
| Chart-feed switch | Off (switch lever to right) |
| SENSITIVITY control | LOW |
| PNEUMO VENT valve | Open (knob in) |
| LOCK RECORD switch | LOCK |
| CARDIO VENT valve | Open (knob out) |
| RESONANCE CONTROL | Closed (knob in) |
| Zero-centering switch | MANUAL ZERO |

## 25. Cardiograph Adjustment

*a.* To inflate the blood-pressure system, proceed as follows:

(1) Place the end of the arm cuff that contains the rubber bag on the muscle of the left arm.

(2) Wrap the cloth bandage around the arm and tuck in the end piece. Note that the wrist cuff is held fast by snap fasteners.

(3) Set the LOCK RECORD switch to LOCK and open the RESONANCE CONTROL approximately halfway.

(4) Close the CARDIO VENT and pump release valves and remove the hand-pump pinch clamp.

(5) Set the PUMP SHUT OFF valve to its open position.

(6) Pump up the system while watching the blood-pressure gage for recurring small oscillations (flickering) of the pointer. Never exceed 150-mm Hg pressure on the gage. As soon as the oscillations become from 1-mm to 2-mm wide (distance between dial graduations), stop pumping and close the PUMP SHUT OFF valve. When a series of planned questions is presented to a subject, skilled analysis of the recorded tracings will disclose the degree of deception used by the subject in giving answers to the questions.

(7) Turn the LOCK RECORD switch to RECORD.

(8) Check to see that the cardio pen tip is centered on its zero-reference base line. If it is not, adjust the CARDIO-PEN CENTERING control until the pen is centered.

(9) Have the subject remain quiet and refrain from any voluntary movement.

*b.* To operate the lie detector in this position, proceed as follows:

(1) Turn on the lie detector.

(2) Turn on the chart-drive mechanism.

(3) Observe the width of each pulse pattern; then proceed as follows:

(*a*) If the dicrotic notch (C, fig. 10) is in the lower or upper half of the tracing following each pen movement, decrease or increase the air pressure in the blood-pressure cuff by turning the hand-pump release valve, to shift the dicrotic notch midway on the tracing.

(*b*) If the pen tends to swing too widely, close the RESONANCE CONTROL enough to limit its travel.

(4) Record a short length of chart paper to become familiar with the appearance of a tracing which indicates the rise and fall of relative blood pressure in a normal subject. The pattern should be similar to that shown in C, figure 10.

*c.* Do not extend the above procedure needlessly. Prolonged application of the arm cuff near the systolic pressure level becomes painful. (Systole action is a term pertaining to the regular contractions of the heart and arteries that impels the blood outward.) The adjustment and test operation should be terminated after 15 minutes of inflated blood-pressure application.

*d.* If a longer test period is required, use the wrist cuff and repeat the adjustment procedure given in *a* and *b* above. Slightly higher pressure will be required than with the arm cuff to obtain a normal amplitude on the pen, but the smaller cuff can be tolerated on the wrist much longer without painful sensation.

## 26. Pneumograph Adjustment

*a.* Set the PNEUMO VENT switch to its open (in) position.

*b.* Attach the pneumograph tubing across the subject's chest and hook the bead chain around his back (fig. 1).

*c.* Return the PNEUMO VENT valve to its closed (raised) position.

*d.* Observe a trial tracing and proceed as follows:

(1) While the subject is inhaling, the pneumo recording pen will move upward on the paper; it will move downward when he exhales.

(2) The lowest point of each cycle forms the zero-reference base line. If necessary, adjust the pen by the PNEUMO-PEN CENTERING control to touch the base line printed on the paper (A, fig. 10). This will aid in following the traced pattern throughout the record.

(3) If the traced curve becomes too wide, move the pneumograph tubing on the subject's chest to a point of smaller chest expansion.

## 27. Gsr Adjustment

In this operation, the lie detector responds to changes in skin resistance of the subject's fingers.

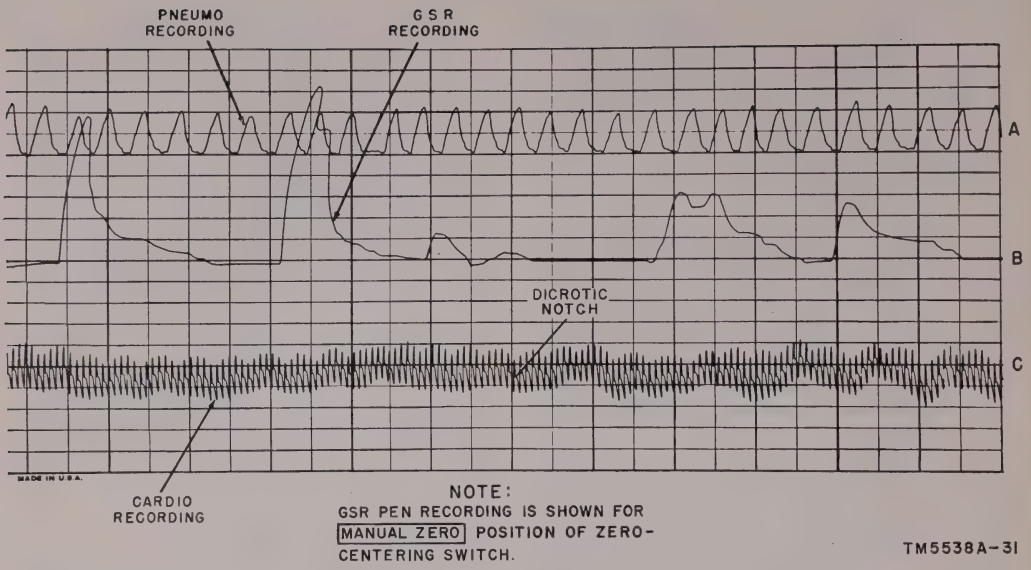


*Figure 10. Typical pen recordings.*

Adjustment of the gsr pen to a zero-reference base line is called the *balancing-in* procedure.

*a.* Before applying the finger electrodes to the subject's index and third fingers, perform the following steps:

(1) Clean his fingers with a cotton wad dipped in alcohol to remove greasy insulating layer on the skin unless the hands were well washed and towel-dried shortly before.

***Caution:*** Keep the alcohol bottle well stoppered to prevent evaporation.

(2) Slip the electrode plates over the first member of the index and third fingers of right hand so that they rest over the cuticle with slight pressure (fig. 11).

*b.* Turn the power switch to ON. Allow at least 3 minutes of warm-up time before proceeding to the next step so that the lie detector can reach a stabilized condition.

*c.* Perform the balancing-in procedure as follows:

(1) Turn the SENSITIVITY control to 20.

(2) Place the zero-centering switch to MANUAL ZERO.

(3) Adjust the CENTERING controls as follows:

(*a*) Rotate the COARSE control until the gsr pen rests as close as possible to the zero-reference base line on the chart paper.

(*b*) Rotate the FINE control until the pen rests on the reference line.

(4) Changes in resistance between the subject's fingers after a short while will move the gsr pen off-center. (An increase in resistance will cause the pen to move down on the chart paper from the previous position.) When this occurs, repeat the balancing-in adjustment.

*d.* If the gsr pen remains in the lower part of the chart paper after advancing the COARSE control to the maximum clockwise position, perform the following steps:

(1) Remove the finger electrodes and apply electrode jelly to the subject's fingers to lower the resistance between them as follows:

(*a*) Vigorously rub a small amount of the jelly on the underside of the fingers (where the electrode plates touch the skin).

(*b*) Remove any surplus jelly around this

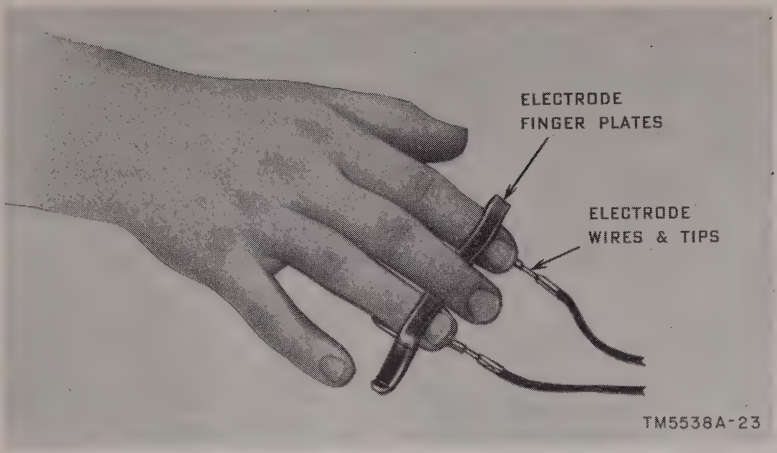


*Figure 11. Application of finger electrodes.*

skin area and reattach the finger electrodes.

(2) Balance-in the subject as described in *c* above. If the gsr pen still does not center on the base line, apply more jelly as in (1) above and repeat the balancing-in procedure.

*e.* Because the susceptibility of different subjects will vary widely and may even change during the testing, it is necessary to adjust the SENSITIVITY control to suit the individual subject. Older subjects usually require a higher SENSITIVITY control setting than the young, although some factors may influence this rule adversely. Operate this control during the following tests to obtain a marked tracing, similar to that shown in B, figure 10.

*f.* Have the subject sit quietly now. Ask him to take a moderately deep breath and note the gsr pen swing after a period of 1 or 2 seconds. A 1- to 2-inch movement of the pen is ample. Repeat this procedure at the same SENSITIVITY control setting but with the zero-centering switch at the AUTOMATIC ZERO position. Note that after stimulus swing of pen, it will remain above the zero or base line of the chart paper and will stay there unless subject's resistance varies rapidly. It is important in this and other tests that the subject remain quiet and avoid any muscular movements.

*g.* A trial run may now be made by using acoustic (clapping hands) or cutaneous (pricking skin) stimuli to the subject and watching the response. Allow sufficient time before giving him the next stimulus. It may take 3 seconds or a much longer period to wear off the effects of the stimulus given. A superimposition of stimuli normally is to be avoided unless the scheme of questioning requires different treatment.

*h.* Make trial runs as described in *a* through *g* above by using both techniques: MANUAL and AUTOMATIC ZERO settings for pen return. The acquired efficiency will help greatly later when important and actual records are to be produced which will allow intelligent diagnosis and become the basis for influential reports.

## 28. Operation

After the adjustments have been performed as directed in paragraphs 25 through 27, the examiner may continue into the recorded tests. There is no fixed normal behavior tracing because every subject under controlled test procedure establishes his own. An entire test depends on the skill of the examiner and the smooth efficiency in handling the task at hand. The following are operating hints to observe. The few mentioned do not eliminate additional refinements acquired by repeated test runs.

*a.* Conserve chart paper between and after tests.

*b.* Readjust the centering control of the pen, the tracing of which tends to run off the paper.

Note the point of the readjustment on the chart paper.

*c.* Readjust the SENSITIVITY control when the gsr pen tracing is too shallow or the pen swings to the edge of the chart paper. Note also this readjustment.

*d.* Use a code or marking scheme on the chart paper to indicate the point at which and what question was asked. Use an easy writing pen to prevent stopping or interfering with the chart paper progress.

*e.* Set the SENSITIVITY control at the lowest point consistent with obtaining marked swings of the gsr pen after *impressive* stimuli. A wide swing of the pen will show an excessive response which may confuse the examiner and result in incorrect interpretation.

*Note.* When the SENSITIVITY knob setting is very low, the FINE control is practically ineffective. When increasing the SENSITIVITY adjustment is increased later on, the FINE centering knob becomes a very useful control for positioning the gsr pen with extreme accuracy.

*f.* When analyzing a record, note that the gsr pen writes about ½ inch ahead of the other pens. Allow for the delay in recording when the pens write at their extreme arc limits.

*g.* Identify a record by the name of the subject, time, and other data for later reference.

*h.* A microphone is mounted behind the dummy knob on the front panel which may be connected through its jack (fig. 5) to a tape or wire recorder or an af amplifier (par. 10). Inflection in questioning and other acoustic events during the testing procedure will help materially when reviewing and analyzing the traced record.

## 29. Stopping Procedure

*a.* Turn the SENSITIVITY control to LOW.

*b.* Shift the chart-drive switch lever to the right.

*c.* Turn the power switch to OFF.

*d.* Turn the LOCK RECORD switch to LOCK.

*e.* Release the air pressure in the cardio system by opening the CARDIO VENT, PUMP SHUT OFF, and pump-release valves.

*f.* Remove the cuff from the subject.

*g.* Open the PNEUMO VENT valve and remove the pneumograph chest assembly from the subject.

*h.* Remove the finger electrodes and, if electrode jelly was used, wipe off the jelly from the subject's finger and from the surfaces of the electrode plates.

*i.* If the lie detector is to be moved to another site, proceed as follows:

(1) Clean the equipment (par. 30).

(2) Remove the cable assemblies, pens, inkwell, paper chart roll, and store them and the loose accessories in the accessory compartment.

(3) Retract the pen guard and replace and fasten the top cover.

## 30. Cleaning the Equipment

Unless the equipment is to be used again within the day, clean the components as follows:

*a.* Flush the pens by forcing clean water through them with the pen starter.

*b.* Wash out the inkwell and remove all dried ink.

*c.* Clean the pen starter and pen filler internally by sucking in water and expelling it until it runs clear.

*d.* Remove all spilled and dried ink near the inkwell.

*e.* Clean the accessory compartment and arrange the contents neatly.

*f.* Clean the exterior of the equipment.

# CHAPTER 4
# ORGANIZATIONAL MAINTENANCE

## Section I. TOOLS, MATERIALS, AND TEST EQUIPMENT

### 31. General

The tools, parts, supplies, and test equipment necessary to perform organizational maintenance are authorized by appropriate publications.

### 32. Tools, Materials, and Test Equipment Required

The following tools, materials, and test equipment are required for organizational maintenance:

| Nomenclature | Technical manual | Common name |
|---|---|---|
| 1 Tool Equipment TE–113 | | |
| Fine sandpaper | | |
| Cleaning Compound (Federal stock No. 7930–395–9542) | | |
| Electronic Multimeter TS–505/U | TM 11–5111 | Vtvm |
| or | | |
| Multimeter TS–352/U | TM 11–5527 | Multimeter |
| Electron Tube Test Set TV–7/U | TM 11–5083 | Tube tester |

## Section II. PREVENTIVE MAINTENANCE SERVICES

### 33. Definition of Preventive Maintenance

Preventive maintenance is work performed on equipment (usually when the equipment is not in use) to keep it in good working order so that breakdowns and needless interruptions in service will be kept to a minimum. Preventive maintenance differs from troubleshooting and repair since its object is to prevent certain troubles from occurring.

### 34. General Preventive Maintenance Techniques

*a.* Use No. 000 sandpaper to remove corrosion.

*b.* Use a clean, dry, lint-free cloth or brush for cleaning. If necessary, except for electrical contacts, moisten the cloth or brush with cleaning compound; after cleaning, wipe the parts dry with a lint-free cloth.

***Warning:*** Prolonged breathing of cleaning compound fumes is dangerous. Make sure adequate ventilation is provided. Cleaning compound is flammable; do not use it near a flame.

*c.* Tighten screws, bolts, and nuts carefully. Fittings tightened beyond the pressure for which they are designed will be damaged or broken.

### 35. Use of First Echelon Preventive Maintenance Form

(fig. 12)

*a.* DA Form 11–238 is a preventive maintenance checklist to be used by the operator.

*b.* Lined out items, or portions thereof, in figure 12 do not apply to the lie detector.

### 36. Use of Second and Third Echelon Preventive Maintenance Form

(fig. 13)

*a.* DA Form 11–239 is a preventive maintenance checklist to be used by second and third echelon repairmen.

*b.* Items that do not apply to the lie detector are lined out on figure 13. References in the ITEM block in the figure refer to paragraphs in this manual that contain additional information about the item.

### 37. Performing Preventive Maintenance

***Caution:*** Remove the pens and the inkwell before turning the lie detector over.

## OPERATOR FIRST ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
### RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

*INSTRUCTIONS: See other side*

| EQUIPMENT NOMENCLATURE | EQUIPMENT SERIAL NO. |
|---|---|
| RECORDING LIE DETECTOR AN/USS-2C | 9 |

LEGEND FOR MARKING CONDITIONS: ✓ Satisfactory; X Adjustment, repair or replacement required; (X) Defect corrected.
NOTE: Strike out items not applicable.

**DAILY**

| NO. | ITEM | CONDITION S | M | T | W | T | F | S |
|---|---|---|---|---|---|---|---|---|
| 1 | COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT ~~(receiver, transmitter~~, *carrying cases,* ~~wire~~ *and cable,* ~~microphones~~, *tubes, spare parts,* ~~technical~~ *manuals and accessories).* | | ✓ | ✓ | | | | |
| 2 | LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. | | ✓ | ✓ | | | | |
| 3 | CLEAN DIRT AND MOISTURE FROM ~~ANTENNA, MICROPHONE, HEADSETS, CHESTSETS, KEYS,~~ JACKS, PLUGS, ~~TELEPHONES, CARRYING BAGS,~~ COMPONENT PANELS. | | ✓ | ✓ | | | | |
| 4 | INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: ~~TUBES,~~ LAMPS, ~~CRYSTALS,~~ FUSES, CONNECTORS, ~~VIBRATORS, PLUG-IN COILS AND RESISTORS.~~ | | ✓ | ✓ | | | | |
| 5 | INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, ~~WORN OR CHIPPED GEARS,~~ MISALIGNMENT, POSITIVE ACTION. | | ✓ | ✓ | | | | |
| 6 | CHECK FOR NORMAL OPERATION. | | ✓ | ✓ | | | | |

**WEEKLY**

| NO. | ITEM | CONDITION | NO. | ITEM | CONDITION |
|---|---|---|---|---|---|
| 7 | CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, ~~RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES,~~ AND CABLE CONNECTIONS. | ✓ | 13 | ~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL AND SPECIFIC GRAVITY, AND DAMAGED CASES.~~ | |
| 8 | INSPECT CASES, MOUNTINGS, ~~ANTENNAS, TOWERS,~~ AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. | ✓ | 14 | CLEAN ~~AIR FILTERS, BRASS NAME PLATES, DIAL AND~~ METER WINDOWS, JEWEL ASSEMBLIES. | ✓ |
| 9 | INSPECT CORD, CABLE, WIRE, AND SHOCK MOUNTS FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. | ✓ | 15 | INSPECT METERS FOR DAMAGED GLASS AND CASES. | ✓ |
| 10 | ~~INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS AND REFLECTORS.~~ | | 16 | ~~INSPECT SHELTERS AND COVERS FOR ADEQUACY OF WEATHER-PROOFING.~~ | |
| 11 | INSPECT ~~CANVAS ITEMS, LEATHER,~~ AND CABLING FOR MILDEW, TEARS, AND FRAYING. | (X) | 17 | ~~CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.~~ | |
| 12 | INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ~~ELECTRICAL TRANSFORMERS, POWER STATS, RELAYS, SELSYNS, MOTORS, BLOWERS, CAPACITORS, GENERATORS,~~ AND PILOT LIGHT ASSEMBLIES. | ✓ | 18 | ~~CHECK TERMINAL BOX COVERS FOR CRACKS, LEAKS, DAMAGED GASKETS, DIRT AND GREASE.~~ | |

19 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

**DA** 1 MAY 51 **FORM 11-238** REPLACES DA AGO FORM 419, 1 DEC 50, WHICH IS OBSOLETE.

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*Figure 12. DA Form 11–238.*

## SECOND AND THIRD ECHELON MAINTENANCE CHECK LIST FOR SIGNAL CORPS EQUIPMENT
RADIO COMMUNICATION, DIRECTION FINDING, CARRIER, RADAR

*INSTRUCTIONS.—See other side*

EQUIPMENT NOMENCLATURE: RECORDING LIE DETECTOR AN/USS-2C

EQUIPMENT SERIAL NO.: 9

LEGEND FOR MARKING CONDITIONS: √ *Satisfactory;* X *Adjustment, repair, or replacement required;* ⊗ *Defect corrected.*
NOTE: *Strike out items not applicable.*

| NO. | ITEM | CONDITION | NO. | ITEM | CONDITION |
|---|---|---|---|---|---|
| 1 | COMPLETENESS AND GENERAL CONDITION OF EQUIPMENT ~~(receiver, transmitter,~~ carrying cases, wire and cable, ~~microphones,~~ tubes, spare parts, ~~technical~~ manuals, and accessories). | √ | 19 | ELECTRON TUBES—~~INSPECT FOR LOOSE ENVELOPES, CAP CONNECTORS, CRACKED SOCKETS.~~ INSUFFICIENT SOCKET SPRING TENSION; CLEAN DUST AND DIRT CAREFULLY; ~~CHECK EMISSION OF RECEIVER TYPE TUBES.~~ | √ |
| 2 | LOCATION AND INSTALLATION SUITABLE FOR NORMAL OPERATION. | √ | 20 | ~~INSPECT FILM CUTOUTS FOR LOOSE PARTS, DIRT, MISALINEMENT, AND CORROSION.~~ | |
| 3 | CLEAN DIRT AND MOISTURE FROM ~~ANTENNA, MICROPHONE,~~ HEADSETS, ~~CHESTSETS, KEYS,~~ JACKS, PLUGS, ~~TELEPHONES, CARRYING BAGS,~~ COMPONENT PANELS. | √ | 21 | INSPECT FIXED CAPACITORS FOR LEAKS, BULGES, AND DISCOLORATION. | √ |
| 4 | INSPECT SEATING OF READILY ACCESSIBLE "PLUCK-OUT" ITEMS: ~~TUBES,~~ LAMPS, ~~CRYSTALS,~~ FUSES, CONNECTORS, ~~VIBRATORS, PLUG-IN COILS, AND RESISTORS.~~ | √ | 22 | ~~INSPECT RELAY AND CIRCUIT BREAKER ASSEMBLIES FOR: LOOSE MOUNTINGS; BURNED, PITTED, CORRODED CONTACTS; MISALINEMENT OF CONTACTS AND SPRINGS; INSUFFICIENT SPRING TENSION; BINDING OF PLUNGERS AND HINGE PARTS.~~ | |
| 5 | INSPECT CONTROLS FOR BINDING, SCRAPING, EXCESSIVE LOOSENESS, WORN OR CHIPPED GEARS, MISALINEMENT, POSITIVE ACTION. PAR. 37a | √ | 23 | ~~INSPECT VARIABLE CAPACITORS FOR DIRT, MOISTURE, MISALINEMENT OF PLATES, AND LOOSE MOUNTINGS.~~ | |
| 6 | CHECK FOR NORMAL OPERATION. | √ | 24 | INSPECT RESISTORS, BUSHINGS, AND INSULATORS, FOR CRACKS, CHIPPING, BLISTERING, DISCOLORATION, AND MOISTURE. | √ |
| 7 | CLEAN AND TIGHTEN EXTERIOR OF COMPONENTS AND CASES, ~~RACK MOUNTS, SHOCK MOUNTS, ANTENNA MOUNTS, COAXIAL TRANSMISSION LINES, WAVE GUIDES,~~ AND CABLE CONNECTIONS. | √ | 25 | ~~INSPECT TERMINALS OF LARGE FIXED CAPACITORS AND RESISTORS FOR CORROSION, DIRT, AND LOOSE CONTACTS.~~ | |
| 8 | INSPECT CASES, MOUNTINGS, ~~ANTENNAS, TOWERS,~~ AND EXPOSED METAL SURFACES, FOR RUST, CORROSION, AND MOISTURE. | √ | 26 | CLEAN AND TIGHTEN SWITCHES, TERMINAL BLOCKS, ~~BLOWERS, RELAY CASES,~~ AND INTERIORS OF CHASSIS AND CABINETS NOT READILY ACCESSIBLE. PAR. 37c | √ |
| 9 | INSPECT CORD, CABLE, WIRE, ~~AND SHOCK MOUNTS~~ FOR CUTS, BREAKS, FRAYING, DETERIORATION, KINKS, AND STRAIN. PAR. 37b | ⊗ | 27 | INSPECT TERMINAL BLOCKS FOR LOOSE CONNECTIONS, CRACKS, AND BREAKS. | √ |
| 10 | ~~INSPECT ANTENNA FOR ECCENTRICITIES, CORROSION, LOOSE FIT, DAMAGED INSULATORS, AND REFLECTORS.~~ | | 28 | ~~CHECK SETTINGS OF ADJUSTABLE RELAYS.~~ | |
| 11 | INSPECT ~~CANVAS ITEMS, LEATHER, AND~~ CABLING FOR MILDEW, TEARS, AND FRAYING. | √ | 29 | LUBRICATE EQUIPMENT ~~IN ACCORDANCE WITH APPLICABLE DEPARTMENT OF THE ARMY LUBRICATION ORDER.~~ PAR. 37d | √ |
| 12 | INSPECT FOR LOOSENESS OF ACCESSIBLE ITEMS: SWITCHES, KNOBS, JACKS, CONNECTORS, ELECTRICAL TRANSFORMERS, ~~POWERSTATS, RELAYS, SLEEVE, MOTORS, BLOWERS,~~ CAPACITORS, ~~GENERATORS,~~ AND PILOT LIGHT ASSEMBLIES. | √ | 30 | ~~INSPECT GENERATORS, AMPLIDYNES, DYNAMOTORS, FOR BRUSH WEAR, SPRING TENSION, ARCING, AND FITTING OF COMMUTATOR.~~ | |
| 13 | ~~INSPECT STORAGE BATTERIES FOR DIRT, LOOSE TERMINALS, ELECTROLYTE LEVEL, AND SPECIFIC GRAVITY, AND DAMAGED CASES.~~ | | 31 | CLEAN AND TIGHTEN CONNECTIONS AND MOUNTINGS FOR TRANSFORMERS, ~~CHOKES,~~ POTENTIOMETERS, AND RHEOSTATS. | √ |
| 14 | CLEAN ~~AIR FILTERS, BRASS NAMEPLATES, DIAL AND~~ METER WINDOWS, JEWEL ASSEMBLIES. | √ | 32 | INSPECT TRANSFORMERS, CHOKES, POTENTIOMETERS, AND RHEOSTATS FOR OVERHEATING, ~~AND OIL LEAKAGE.~~ | √ |
| 15 | INSPECT METERS FOR DAMAGED GLASS AND CASES. | √ | 33 | ~~BEFORE SHIPPING OR STORING, REMOVE BATTERIES.~~ | |
| 16 | ~~INSPECT GASKETS AND COVERS FOR ADEQUACY OF WEATHERPROOFING.~~ | | 34 | ~~INSPECT CATHODE RAY TUBES FOR BURNT SCREEN SPOTS.~~ | |
| 17 | ~~CHECK ANTENNA GUY WIRES FOR LOOSENESS AND PROPER TENSION.~~ | | 35 | ~~INSPECT BATTERIES FOR SHORTS AND DEAD CELLS.~~ | |
| 18 | ~~CHECK TERMINAL BOX COVERS FOR GRACKS, LEAKS, DAMAGED GASKETS, DIRT, AND GREASE.~~ | | 36 | ~~INSPECT FOR LEAKING WATERPROOF GASKETS, WORN OR LOOSE PARTS.~~ | |
| | | | 37 | ~~MOISTURE AND FUNGIPROOF.~~ | |

38 IF DEFICIENCIES NOTED ARE NOT CORRECTED DURING INSPECTION, INDICATE ACTION TAKEN FOR CORRECTION.

DA FORM MAY 51 11-239 Replaces DA AGO Form 419, 1 Dec 50, which is obsolete. 20-15-54239-6

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*Figure 13. DA Form 11-239.*

Make monthly checks as follows:

*a.* Inspect the gears; refer to figure 14.

*b.* Inspect the rubber and metal tubings for signs of wear and cracks (fig. 18).

*c.* Do not clean the galvanometer movement and do not use air pressure to blow out the air circuits internally and externally on the metal bellows.

*d.* Lubricate the chart drive as described in paragraph 38 and shown in figure 14.

## Section III. LUBRICATION

### 33. Lubrication Requirements

The paper chart-feed mechanism is the only unit that requires lubrication periodically. The length of time between lubrication periods depends on the extent of the instrument's use and the amount of exposure to high temperatures that tend to thin out oils and greases. Normally, the paper feed gears and shafts need lubrication monthly. Use Light Petroleum Lubricating Oil, VV L 820 and Grease, Aircraft and Instruments (GL).

### 39. Lubrication

Remove all pens and inkwell before starting the lubrication procedure. Turn over the lie detector and remove the bottom cover. Refer to paragraph 67*a* for instructions for lifting the chart-drive unit. Use figure 14 for points that require lubrication.

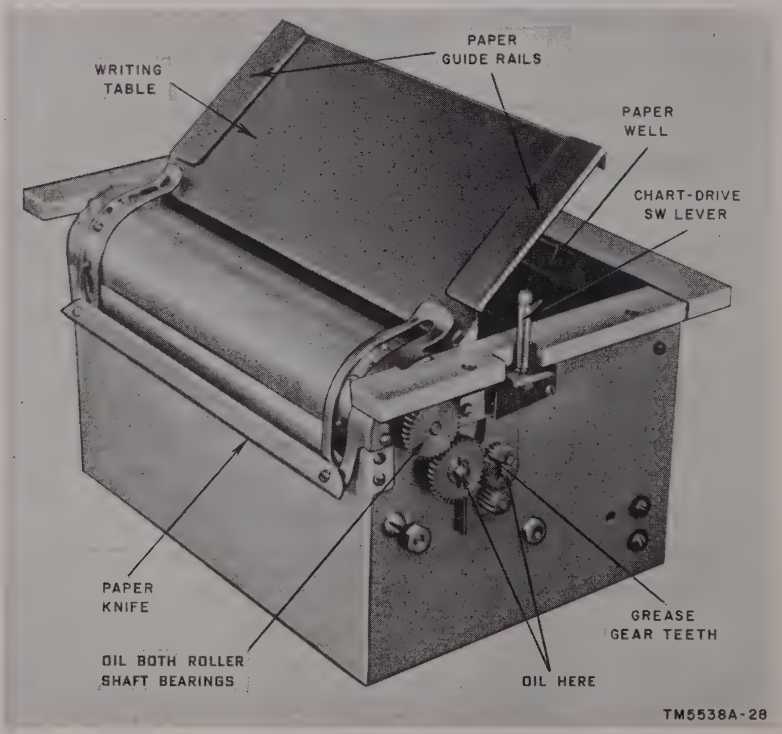



*Figure 14. Lubrication of chart-drive gears.*

## Section IV. TROUBLESHOOTNG AT ORGANIZATIONAL MAINTENANCE LEVEL

### 40. Extent of Instructions

*a.* Troubleshooting at an organizational level is limited to localizing defective parts that can be easily replaced at an organizational level (tubes, fuses, cables, etc), or to sectionalizing defective units that must be replaced as a unit (cardiograph (blood pressure) and pneumograph components). The procedures outlined are designed to determine first the defective unit and then the nature of the fault within the unit. If the fault cannot be determined through the procedures given in paragraphs 41 through 46, corrective measures or the need for repair at a field maintenance level (ch. 6) is indicated.

*b.* The techniques used for organizational troubleshooting the lie detector include visual inspection, operational tests, tube tests, and simple continuity checks. The material in this manual is presented in the order which the repairman should follow when servicing a defective lie detector. When the procedures indicated are not enough to determine the source of trouble, troubleshooting at a field maintenance level is required.

### 41. Inspection

*a.* When the lie detector fails and the cause is not immediately apparent, check as many of the items listed in *b* and *c* below as is practicable before starting a systematic operational check of the equipment. Do not disassemble the set for a complete inspection without some knowledge of the operational symptoms. If possible, obtain information from the operator of the equipment regarding performance at the time trouble occurred.

*b.* Complete or partial failure of the lie detector often may be caused by—

(1) Leaky connection to tubings or accessories.
(2) Worn, broken, or disconnected line cord or plugs.
(3) Blown fuses in input (subject-protecting fuse F1, fig. 21) or ac power circuit (fig. 9).
(4) Defective tubing.
(5) Improperly applied pneumograph or arm (or wrist cuff) assemblies on subject.

*c.* Sometimes the cause of failure is not apparent; therefore, the items in *b*(1) through (5) above should be checked before making a more detailed inspection of the component parts.

### 42. Sectionalization of Trouble to Component

Sectionalization consists of determining whether the trouble is in the pneumographic, cardiosphygmographic, or amplifier-galvanometer component.

*a.* Operate the lie detector and observe its performance.

*b.* If trouble is indicated in any component, make the checks as described in paragraphs 43 through 46.

### 43. Troubleshooting Pneumographic Section

Poor operation of the pneumographic recording pen is usually caused by an air leak in the circuit. Check for the possibility of an air leak as follows:

*a.* Make sure that the PNEUMO VENT valve is closed.

*b.* Tie the pneumograph tube around a solid object, such as a chair back, so that the tube does not stretch more than ¼ inch, and leave it in that position for 2 minutes. After its first movement, the pneumo pen should not return to its base line during the 2-minute period. If it does, a leak is indicated.

*c.* If the check performed as instructed in *b* above shows the presence of a leak, let the pneumograph tube return to its normal length, and stretch it again ¼ inch. Immediately pinch its rubber hose close to the cabinet. If the pen returns to its base line within 2 minutes, the leak is inside the equipment cabinet. If the pen holds its position, the leak is in the pneumograph chest unit or its connecting tubing. To check whether the pneumograph chest unit or the connecting tubing leaks, let the pneumograph tube return to its normal length. Stretch it once more ¼ inch. Immediately pinch the rubber tube close to the point where it connects to the pneumograph panel. If the pen returns to its line within 2 minutes, the leak is in the connecting rubber tube; if the pen holds its position for 2 minutes, the leak is within the pneumograph section. In either case, replace the defective part.

## 44. Troubleshooting Cardiosphygmographic Section

Check for air leaks as follows:

*a.* Check to see that the CARDIO VENT valve is closed, the LOCK RECORD switch is at LOCK, and that the PUMP SHUT OFF valve is open.

*b.* Wrap the arm cuff around a solid object, such as a chair back, remove the pinch clamp, close the pump-release valve, and inflate the cuff for a reading on the blood-pressure gage of about 90-mm. Close the PUMP SHUT OFF valve.

*c.* Set the LOCK RECORD switch to RECORD and note the position of the cardio pen on the chart paper.

*d.* The cardio pen should not move more than 1/4 inch, or one chart division, during 15 minutes; if it does, a leak is in the system, and the following checks should be made:

(1) Pump up the pressure again to about 90 mm. Use the pinch clamp and pinch the hand-pump rubber tubing close to the front panel of the lie detector while watching the cardio pen. If the pen moves more than one chart division during 15 minutes, the leak is not in the hand pump or its tubing. If the pen does not move more than one chart division repeat the process; pinch the tubing near the hand-pump bulb to localize the leak to the bulb or the tubing.

(2) If the leak is not in the hand pump or its tubing, perform the same checks on the cuff and its tubing. Replace any part found to be defective.

(3) If the leak is not in the external tubing or parts, it is under the panel; technical repair service is needed.

## 45. Troubleshooting Amplifier-Galvanometer Section

Poor performance of the gsr component may result if the equipment is used where strong magnetic fields are present such as those created by electric wires carrying heavy currents and by nearby radio stations. Complete shielding and grounding of the shield may be necessary, or the lie detector may have to be relocated. Check the gsr parts as follows:

*a.* Check the line voltage for 117 volts ac. A tolerance fluctuation of ±10 per cent is permissible. Check the 3-ampere power fuse (fig. 9).

*b.* Inspect the electrode stainless-steel plates, the wiring, and the plug for signs of corrosion and dirt.

*c.* If the response of the gsr to centering and sensitivity adjustments is poor, the difficulty may be corrected by testing the tubes (par. 46). Remove the bottom cover and see that the tubes are well seated in their sockets (fig. 18). Tube 5651 (V3, fig. 21) shows an orange color when under power. If not, this tube should be replaced. Check to see that the subject-protecting fuse (fig. 21) is good and that it is rated at 1/200 amperes. Visually inspect soldering joints. If no apparent defect can be located and trouble persists, higher echelon repair is required.

*d.* Replace a burned-out pilot light with one of the same type. Unscrew the plastic guard of the lamp and remove the bayonet-base bulb by pressing it in and turning it to the left.

## 46. Tube Testing Techniques

When trouble occurs, check all cabling and connections before removing any tubes. Try to isolate the trouble to a component or stage. If tube failure is suspected, use the applicable procedure below to check the tubes.

***Caution:*** Do not rock or rotate a tube when removing it from a socket; pull it straight out with a tube puller.

*a. Use of Tube Tester.* Remove and test one tube at a time. Discard a tube only if its defect is obvious or if the tube tester shows it to be defective. Do not discard a tube that tests at or near its minimum test limit on the tube tester. Put back the original tube, or insert a new one if required, before testing the next one.

*b. Tube Substitution Methods.* Replace a suspected tube with a new tube. If the equipment remains inoperative, remove the new tube and put back the original tube. Repeat this procedure with each suspected tube until the defective tube is located.

# CHAPTER 5
# THEORY

## Section I. CARDIOSPHYGMOGRAPHIC SECTION

### 47. General

*a.* The lie detector is divided into three main sections each of which can function independently of the other (fig. 15). The cardiograph (par. 48) and pneumograph (par. 49) units are considered as mechanical sections while the gsr unit (pars. 50–56) is considered as an electronic section. The chart-drive mechanism can be considered a fourth section but is described in conjunction with the three main operating sections.

*b.* The pens are filled by squeezing the bulb of the starter and then inserting the pen point in the hole in the plastic insert. Ink is drawn up the pen tubing by the vacuum created when the bulb is released (fig. 8). After this procedure is completed, the normal ink flow is drawn from an ink cup below the cradle through the hollow pen to the pen point by capillary action.

### 48. Theory of Cardiosphygmographic Section (fig. 15)

*a.* The pulse rate and blood-pressure change impulses are received from the subject's brachial artery through the blood-pressure cuff. The impulses are transmitted through the cuff tubing to a sensitive bellows-operated lever system that operates a writing pen. A hand-pump bulb is provided to inflate the system so that the pressure in the cuff is varied by each pulse beat and

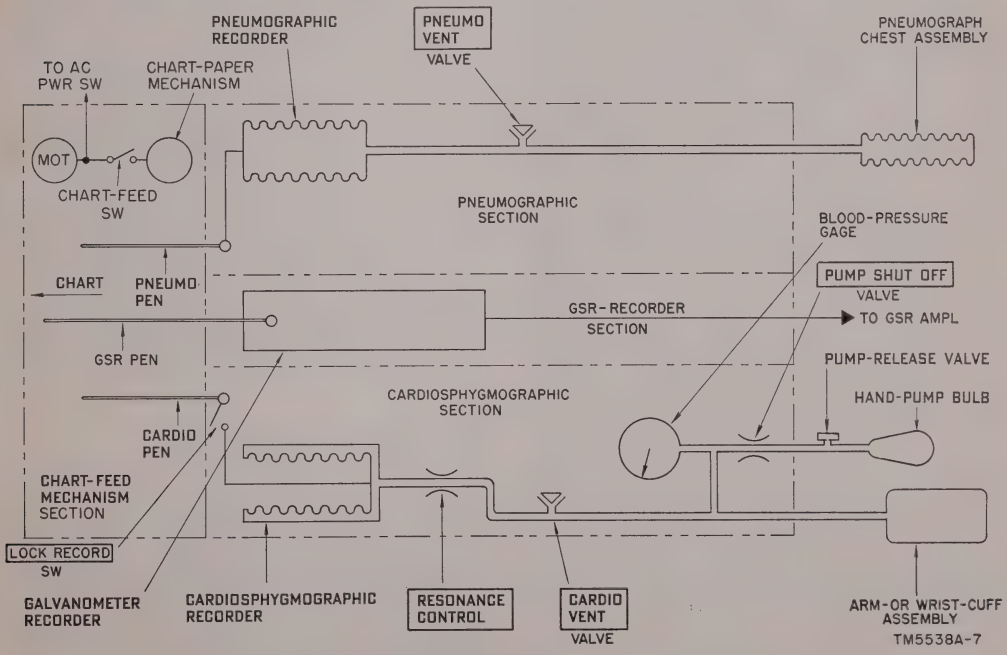



*Figure 15. Mechanical sections, block diagram.*

by changes in the subject's blood pressure. The blood-pressure gage (sphygmo-manometer) registers the amount of pressure in mm of Hg in the system. The CARDIO VENT and the hand-pump release valves permit rapid release of the air pressure when the test is finished. The RESONANCE CONTROL changes the diameter of the tubing connected to the bellows so that the distance of travel of the writing pen may be controlled. The PUMP SHUT OFF valve closes the circuit to maintain pressure. When set at LOCK, the LOCK RECORD switch prevents the cardio pen from whipping when the cuff is inflated. In the RECORD position, the switch seals the cardio system airtight to permit normal operation of the system.

*b.* When a blood-pressure cuff is applied to a subject's arm or wrist and properly inflated, the cardio recording pen traces a record of pulse rate and blood-pressure changes. The blood-pressure gage indicates the proper inflation point of the arm or wrist cuff. Although the arm cuff provides more satisfactory recordings, the wrist cuff permits use of the lie detector over longer periods without excessive discomfort to the subject.

### 49. Theory of Pneumographic Section

The air pressure within the rubber tubing changes as the chest expands and contracts because of the breathing cycle of the subject. The rate of these changes in pressure are transmitted through tubing to the recorder bellows and lever system that operates the pneumo writing pen. The PNEUMO VENT valve, which is opened in normal operation, should be closed when the pneumograph is handled, so that the wide changes in pressure resulting from handling will not cause the pen to swing wildly.

## Section II. AMPLIFIER-GALVANOMETER SECTION

### 50. Block Diagram of Gsr Section (fig. 16)

The gsr section senses small changes in skin resistance from the general resistance level when the subject is under test. A simple Wheatstone bridge circuit uses the electrodes and compensating resistances in one arm and is arranged so that the subject's resistance across the electrode plate can be balanced against the other bridge arms. This results in an electrical balance and no signal is then present. A small change in the subject's resistance, however, will cause a positive or negative unbalance which will be picked up by the chopper circuit and fed a a rectilinear wave into the first and second voltage-amplifier stages. A power and phase detector stage receives this signal, greatly magnified, and translates it into an output signal according to polarity and magnitude. The galvanometer-recorder receives this impulse and its pen will swing from zero position, depending on the polarity and magnitude of signal. The size of the input signal to the cathode-connected galvanometer coil is proportioned to the unbalance existing at the input bridge output. The length of the arc of the gsr pen swing from a zero-reference base line is therefore normally a measure of the subject's response to a stimulus as transmitted by the electrodes from a general resistance level.

### 51. Input Bridge Circuit with Electrodes (figs. 17 and 28)

An arrangement of fixed resistors R2, R7, R14, variable resistors R3 and R4, fuse F, and electrodes form the four arms of a Wheatstone bridge (fig. 17). Electrode connector J1 is placed opposite the positive voltage supply (+21 volts) within the bridge circuit. The output of the bridge is fed to the chopper circuit through a network formed by resistors R5 and R6 and capacitor C2, to filter out 60-cycle pickup by the subject. Capacitor C1 and resistor R10 provide a time-constant circuit when switch S1 is set at AUTOMATIC ZERO. When this switch is set to MANUAL ZERO, the gsr pen will not drift slowly off a zero-reference base line on the chart paper but will remain at the position until readjusted.

### 52. Chopper-Converter Circuit (fig. 28)

*a.* The principal parts are two silicon diodes CR1 and CR2. Approximately 5.8 volts ac from power transformer T1 is fed to the diodes through limiting resistors R9 and R10. The diodes function in a bridge circuit as a 60-cycle, single-pole, single-throw (spst) shorting switch across the input of the first voltage amplifier.

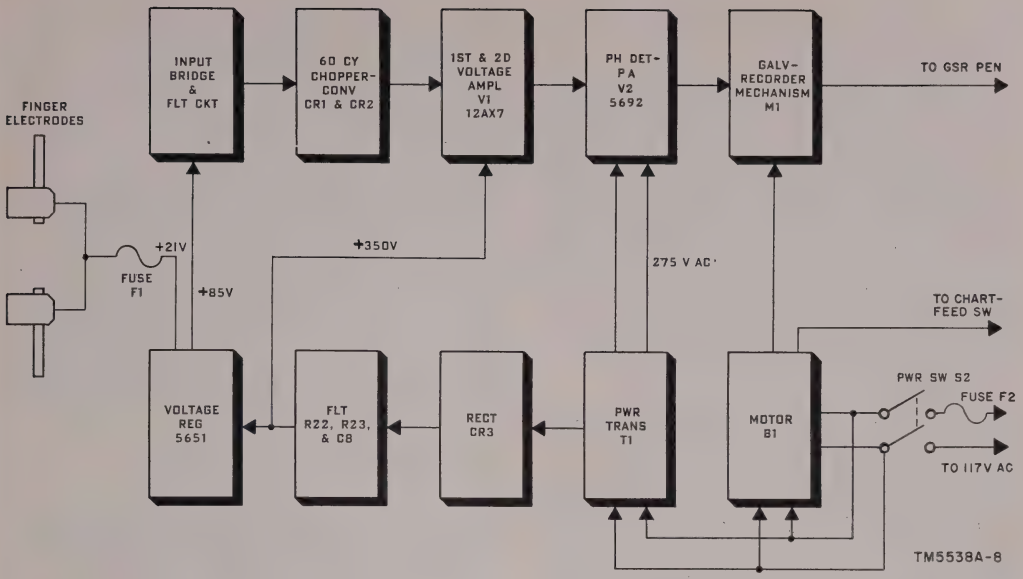



*Figure 16. Grs section block diagram.*

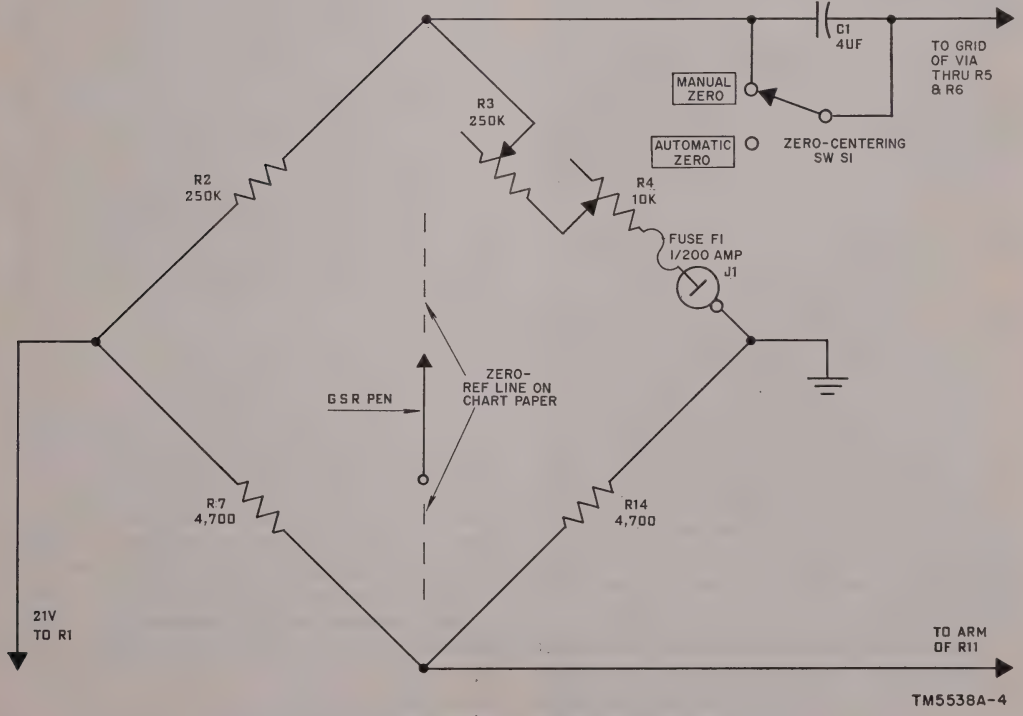



*Figure 17. Wheatstone bridge, simplified schematic diagram.*

This action synchronizes with the conducting phases of the output stage.

*b.* Fixed resistors R12 and R13 and variable resistor R11 allow suitable interconnection into the output terminals of the bridge circuit. For bridge zero output (balanced-in position), R11 is screwdriver adjusted for zero output (B, fig. 23) at the grid input side to the first voltage amplifier. From this point, all amplification occurs at 60 cycles and capacitor C4 will pass only the desirable rectilinear wave form to the first voltage-amplifier tube.

### 53. Voltage Amplifiers
(fig. 28)

Both triode sections of 12AX7 V1 tube are used to amplify the 60-cycle chopped signal fed through C4. The pulsating signal (A, fig. 23) is fed into the first grid (pin 2) of V1A which will swing more or less negative in relation to its grounded cathode (pin 3). Its plate (pin 1) will follow these voltage fluctuations correspondingly between positive and negative swings. The amplification of this stage is repeated in the second section (V1B) of the same twin triode, providing a maximum voltage gain of about 2,000. Potentiometers R17 and R18 permit sensitivity or gain adjustments. The slider of R18 is connected to the second grid (pin 7) and may be set from low or zero sensitivity position up to maximum or high after R17 has been adjusted (par. 66*b*).

### 54. Phase Detector-Power Amplifier Stage
(fig. 28)

*a.* Both sections of twin triode 5692 (V2) receive the same signal on their grids through branching at point *E*. The signal passes through capacitors C7 and C9 and then to the grids (pin 1 of V2A and pin 4 of V2B). Cathode loads are formed by the galvanometer coil (1,000 ohms), which is center-tapped and grounded through R30. A network around variable resistor R25 allows adjustments in positive grid return for V2A, to provide compensation for electrical differences between the two sections. Screwdriver-operated resistor R25 equalizes this incidental unbalance between the two triode sections.

*b.* The plates (pins 2 and 5) of this tube are directly connected to the high-voltage ac winding of power transformer T1, fed in opposite phase. The midpoint of the secondary winding of T1 is grounded. When a signal is impressed on both grids of V2, the polarity of this signal determines which half of V2 is affected. When this signal is positive against balance condition, the only positive half-cycles are generated by the chopper-converter and appear as such at both grids of V2. The tube half which is at that instance going through a positive half-cycle will conduct, the other half of this tube cannot conduct as its plate at that instance is negative. This synchronous action is controlled by the power line 60-cycle frequency through T1 acting on the chopper-converter and the plates of V2 alike, and results in a polarity-sensitive operation.

### 55. Galvanometer-Recorder Unit
(fig. 28)

Recording galvanometer coil M1 is electrically connected into both cathodes of V2. Its coil resistance makes up the cathode resistances. The center-tap lead of this coil is grounded through resistor R30. With no signal present the gsr pen will track on the zero-reference base line of the chart paper strip, because no mechanical torque is applied to its center shaft. If, however, a signal causes one section of V2 to conduct then the cathode current flowing through the galvanometer coil system will be magnetically forced out of its center or zero position. The pen will swing up or down on the chart strip, depending on the polarity of unbalance, and the length of the arc will reflect the amount of the unbalance. The subject's change in resistance will be recorded by the gsr pen.

### 56. Power Supply
(fig. 28)

Power transformer T1 furnishes all plate and filament voltages. Plate voltage for V2 is taken from the 275-volt center-tapped secondary winding of T1 and plate voltage for V1 is rectified and filtered at approximately +350 volts direct current (dc). A stabilized dc voltage is obtained through resistor R1 and regulated by tube 5651 (V3). Voltage-dropping resistor R21 connects to pin 5 of this tube. This connection energizes the input bridge (par. 51) at a few milliamperes drain.

# CHAPTER 6
# FIELD MAINTENANCE

## Section I. TROUBLESHOOTING AT FIELD MAINTENANCE LEVEL

### 57. Troubleshooting Procedures

The first step in servicing a defective lie detector is to sectionalize the fault. Sectionalization means tracing the fault to the *major component or circuit* responsible for the abnormal operation of the set. For troubleshooting, the lie detector can be considered as divided into five sections: pneumograph (fig. 19), cardiograph (fig. 20), gsr amplifier (fig. 22), galvanometer-recorder (fig. 25), and paper-chart mechanism (fig. 14). The second step is to localize the fault. Localization means tracing the fault to the defective *part* responsible for the abnormal condition. Some faults, such as burned-out resistors and shorted motor, often can be located by sight, smell, and hearing. The majority of faults, however, must be localized by checking voltage, resistance, and mechanical operation of the set.

*a. System Sectionalization.* System sectionalization is described in paragraphs 43 through 45.

*b. Component Sectionalization.* The tests listed below will aid in isolating the source of trouble. To be effective, the procedure should be followed in the order given. First, trouble should be localized to a single air circuit or amplifier stage. Then the trouble may be isolated within that stage or circuit by appropriate mechanical check or voltage, resistance, and continuity measurements.

(1) *Visual inspection* (par. 41). Through this inspection alone, the repairman may frequently discover the trouble or determine the air circuit or amplifier stage in which the trouble exists. This inspection is valuable since it prevents additional damage to the set (which might occur through improper servicing methods) and forestalls future failures.

(2) *Operational test* (pars. 24–28). In many instances the information gained from the operational tests will determine the exact nature of the fault. To use this information fully, all symptoms must be interpreted in relation to one another.

(3) *Troubleshooting guide.* The symptoms listed in paragraphs 61 through 67 will aid greatly in localizing trouble.

(4) *Intermittents.* In all these tests, the possibility of intermittents in the lie detector should not be overlooked. If present, this type of trouble often may be made to appear by tapping or jarring the set.

### 58. Troubleshooting Data

Take advantage of the material supplied in this manual. It will help in the rapid location of faults. Consult the following troubleshooting data:

| Fig. No. | Fig. caption |
|---|---|
| 15 | Mechanical sections, block diagram. |
| 16 | Gsr section, block digaram. |
| 18 | Lie detector, bottom view. |
| 19 | Pneumographic panel, bottom view. |
| 20 | Cardiographic panel, bottom view. |
| 21 | Gsr amplifier top, parts location. |
| 22 | Gsr amplifier bottom, parts location. |
| 23 | Chopper-converter waveforms. |
| 24 | Voltage and resistance measurement chart. |
| 25 | Galvanometer-recorder panel, bottom view. |
| 26 | MIL-STD resistor color codes. |
| 27 | MIL-STD capacitor color codes. |
| 28 | Grs amplifier, main schematic diagram. |

### 59. Test Equipment Required for Troubleshooting

The test equipment required for troubleshooting the lie detector is the same as used in organizational maintenance (par. 32) except that Oscilloscope OS–8A/U, TM 11–1214 is added.

## 60. Repair of Components

*a.* Refer to paragraphs 41 through 46 for inspection, sectionalization of trouble, and tube testing techniques.

*b.* When no exterior subassembly or part of an air or electric circuit is found defective, raise the unit panel of the component in question and turn it over to expose the mechanism attached to underside (fig. 18).

*c.* Before lifting any unit panel from the instrument frame, obtain wooden cleats to space the unit panel from the top of the work bench. Protect all pen cradles and controls. Clean the top of the work bench.

*d.* Remove the inkwell and pens.

***Caution:*** A strong permanent magnet is mounted near the center of the instrument and is part of the galvanometer. Do not expose watches, tools, or other steel articles to this magnetic field.

*e.* Remove the countersunk screws that hold down the unit panel to be worked on. Raise the panel about 5 inches and then disconnect the rubber tubing, electrical wires, or both, depending on the unit to be removed.

*f.* The unit is now free and should be placed on the wooden cleats.

*g.* Reconnect the accessories, rubber tubing, or wires as needed, to perform the troubleshooting checks and repairs on the system.

## 61. Repair and Check of Pneumographic Unit

*a. Locating Air Leaks.* Connect the hand-pump bulb to the pneumograph hose connector. Inflate the air circuit moderately; be careful not to distort the brass bellows of the pneumograph recording unit (fig. 19). Turn the PNEUMO VENT valve to its closed position. Use the pinch clamp to pinch the rubber hose on the hand-pump bulb. Use soapy water and a brush to detect the leaks by brushing along the rubber tubing, the entrance to the bellows unit, the bellows, and at the rear of the PNEUMO VENT valve.

(1) If a leak is found in the rubber tubing, replace the old tubing with new tubing.

(2) If a leak is found on the entrance connection to the bellows unit, remove the

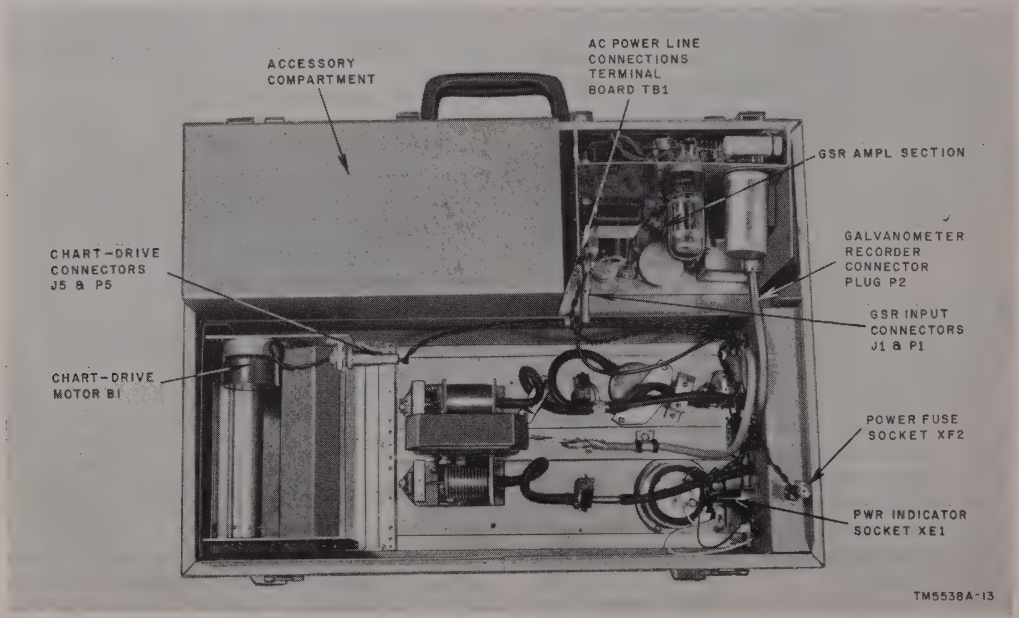



*Figure 18. Lie detector, bottom view.*

tubing and solder the leaky joint. Be careful when soldering, because excessive heat may unsolder the bellows from its plate.

(3) If the leak is found to be in the brass bellows unit, replace the panel unit as described in *d* below.

(4) If the leak is traced to a worn rubber disk between the leaf spring and opening on the PNEUMO VENT valve, replace this rubber disk. Remove the valve from the panel to replace the rubber disk to avoid distorting this leaf spring.

*b. Adjustment of Center Shaft Play* (fig. 19). The center shaft is pivoted on jewel bearings. *Never oil these bearings.* When adjustments are made, be careful not to crack the jewels by overtightening them. Check the free turning of the center shaft for excessive side play. If the play is excessive (.001 inch), tighten the center shaft adjustment a part of a turn.

*c. Adjustment of Pen Travel.* After repairing the pneumographic unit, check the pen travel. The maximum limits of pen travel should not be beyond an imaginary line located ¼ to ⅛ inch from the perforated edge of the paper. Readjust the pen travel limiting screws (fig. 19) as required, and lock the screws with glyptal or shellac.

*d. Replacement of Pneumographic Unit.* To replace the pneumographic unit, remove the old unit as follows:

(1) Remove all pens and the inkwell before turning over the lie detector to remove the bottom cover.

(2) Slip off the interconnecting pneumograph rubber tubing (figs. 18 and 19).

(3) Unsolder the two wires that connect the microphone. Be sure that no heat is applied to the microphone crystal; the heat will damage it.

(4) Remove the mounting screws from the base of the unit and lift the assembly from the panel.

(5) When mounting the new unit, reverse the procedure given in (1) through (4) above. When connected, test for leaks (*a* above) and check the pen travel adjustment (*c* above).

## 62. Repair and Check of Cardiosphygmographic Unit

*a. Locating Air Leaks.* If the checks performed as instructed in paragraph 44 show that the air leak is under the panel, make sure that the CARDIO VENT valve is closed and that the RESONANCE CONTROL and the PUMP SHUT OFF valve are open. Check for the leak as follows:

(1) Pinch the cuff tubing close to the panel. Inflate the air circuit with the hand-pump bulb. Pinch the pump bulb hose close to the panel.

(2) Observe the reading on the gage. A slow diminishing of pressure will indicate a leak.

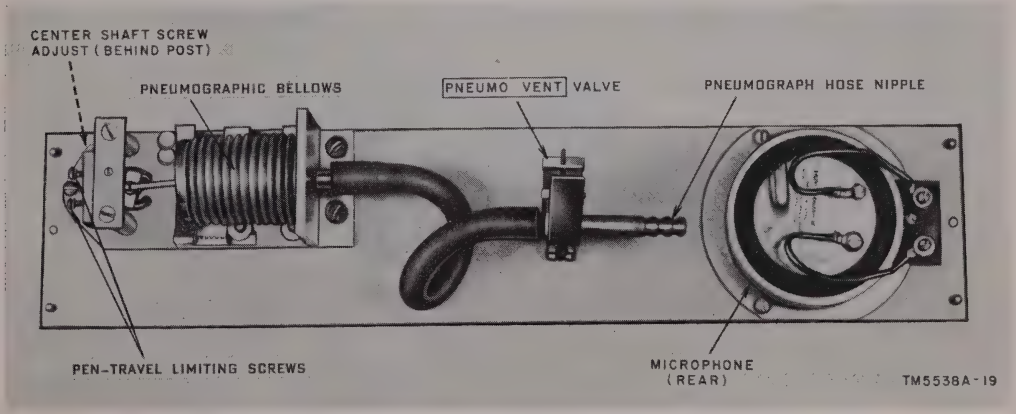



*Figure 19. Pneumographic panel, bottom view.*

(3) Localize the leak first by closing the PUMP SHUT OFF valve and then by closing the RESONANCE CONTROL.

(4) Check the rubber tubes under the PUMP SHUT OFF valve and the RESONANCE CONTROL. Replace the tubing if it is found to be cracked or worn.

(5) Check the soldered joints of the hose nipples for leaks; use a brush and soapy water. Resolder if a leak is found.

(6) If the leak is found on the entrance joint to the brass bellows, seal the joint by resoldering it. Be careful not to unsolder the bellows unit. Work quickly.

(7) If the leak is found in the brass bellows, replace the entire unit.

(8) If the leak is found in the blood-pressure gage, unsolder the gage connections and replace it with a gage known to be in good working order.

*b. Adjustment of Center Shaft Play.* The adjustment procedure for the cardiosphygmographic center shaft end play is the same as that for the pneumographic unit (par. 61*b*).

*c. Adjustment of Pen Travel.* Pen travel requirements for the cardio unit are the same as those for the pneumographic unit (par. 61*c*).

*d. Replacement of Cardiosphygmographic Unit.* If the cardiosphygmograph panel must be replaced, remove the mounting screws to remove the panel unit. When mounting the new one, reverse the procedure and test the pen travel limit adjustment (par. 61*c*).

*e. Replacement of PUMP SHUTOFF Valve and RESONANCE CONTROL.* These controls are replaceable. The valve seats may become worn and require replacement. Prolonged tight seating will vulcanize the compressed rubber tubing. If this condition exists or the rubber tubing becomes sticky internally and does not readily open when the valve is opened, replace it with fresh tubing.

*f. Final Testing.* Check the entire cardiosphygmograph air circuit before reassembling the panel to the cabinet. The permissible drop in pressure of the system with an initial pressure of 90-mm Hg is .75-mm Hg over a 15-minute interval.

## 63. Troubleshooting Gsr Section

The following procedure for sectionalizing trouble will enable the repairman to localize the fault:

*a.* Turn the power switch to ON. Place the gsr pen into its cradle. Position the SENSITIVITY control on LOW and set the zero-centering switch to MANUAL ZERO.

*b.* Make a continuity test through the finger electrode wires for each conductor before attaching the connector to the instrument. Check to see that good contact can be made and the cord is in good condition. If serviceable, slip off both

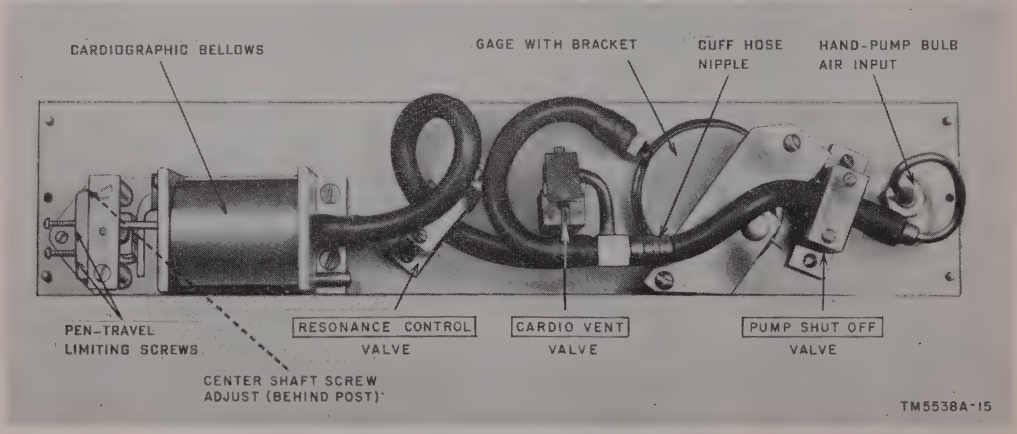



*Figure 20. Cardiographic panel, bottom view.*

stainless-steel plates and insert the telephone tips into jacks J7 and J8 (fig. 28) on the checking fixture (dummy subject provided as part of the pen retainer box (fig. 4)). Two fixed resistors are now in series with the electrode terminals. Balance-in these resistors on the amplifier so that the pen tracks at the zero-reference base line. Move the dummy-test slide switch (S3) to the right and see that the gsr pen moves

*c.* If the test check in *b* above fails, check galvanometer plug P2 (fig. 18) for continuity of the coil. Remove plug P2 and check coil M1 (fig. 28) for continuity and shorts to chassis ground. If no defects are found, the fault is in the amplifier component. To repair a defective coil, refer to paragraph 64.

*d.* Disconnect power line connections at terminal strip TB1 (fig. 21) and disconnect the electrode screw connector, and turn over the instrument again. Remove the six screws that hold the gsr amplifier unit to the chassis. Lift out the unit and connect temporary ac line wires to TB1. Also remove the galvanometer-recorder unit (fig. 25) and reinsert plug P2. Reconnect the electrode screw terminal and use the vacuum-tube voltmeter (vtvm) to check the resistances and voltages (figs. 24 and 28) of each stage. Check to see that all tube filaments are lighted and all solder joints are intact and sound. Test all tubes (par. 46).

*e.* If the defect has not been found, refer to figure 28 and proceed as follows:

(1) Dc voltage at point *A* should be +21 volts; if not, trace this failure back towards the power supply.

(2) If the voltage at point *A* is correct, attach the vtvm dc leads to points *C* and *B*. Balance the internal bridge with the zero-centering switch at MANUAL ZERO against the external resistor when checking fixture on the lowest reading scale on the vtvm. If this does not balance, a resistor or soldering joint is open.

(3) After this correction, use the oscilloscope on point *C* and instrument ground. With the external resistance and internal bridge at balance, a nearly horizontal straight line will appear on the oscilloscope. With the 1,000-ohm resistor on the checking fixture shorted out, (S3 moved to the right) a rectilinear wave (A, fig. 23), either above or below the base line, will be traced. Use the CENTERING controls to widen this tracing for better observation and to show the operation of the chopper-converter circuit. Adjust chopper variable resistor R11 (fig. 21) with a screw driver at balanced- in condition for a nearly straight line (B, fig. 23) and observe the shape of the wave at the unbalanced state with either a positive or negative signal impressed.

*f.* Turn the SENSITIVITY control to HIGH and continue to follow this signal to the last stage. Refer to paragraph 54 and apply this treatment to check the proper transformation of the low-voltage input signal to the final output terminals at pins 3 and 6 of V2. At point *F* (fig. 28), a greatly magnified wave is fed into both halves of V2. Thus V2 detects the phase and passes only the signal of proper polarity.

*g.* If voltage at point *F* is below 350 volts, check section A and C of selenium rectifier CR3 and section C of capacitor C8. Rectifier CR3 is checked easiest by a dc voltage measurement. The rectifier units under power should each indicate about 140 volts. If the reading is much lower than 85 volts, replace the unit. Test the output voltages on power transformer T1. Replace T1 if the secondary high voltage is considerably lower than the normal values.

*h.* All the above defect-detecting tests can be performed without galvanometer coil M1 connected, if a 10-milliampere, full-scale meter is connected across two series-connected, 1-watt, 500-ohm resistors. The two free terminals connect to pins 2 and 3 on galvanometer socket J2 and the center of the two resistors attaches to pin 1 of J2. The milliammeter will then indicate the operation of the system and provide grid returns to complete the circuit.

## 64. Repair or Replacement of Galvanometer-Recorder Unit

If the checks made as outlined in paragraph 63 reveal an open or grounded coil in the galvanometer unit, proceed as follows:

*a.* To reach the coil interior, remove the unit from the instrument frame and open the aluminum cover plate held down by four screws (fig.

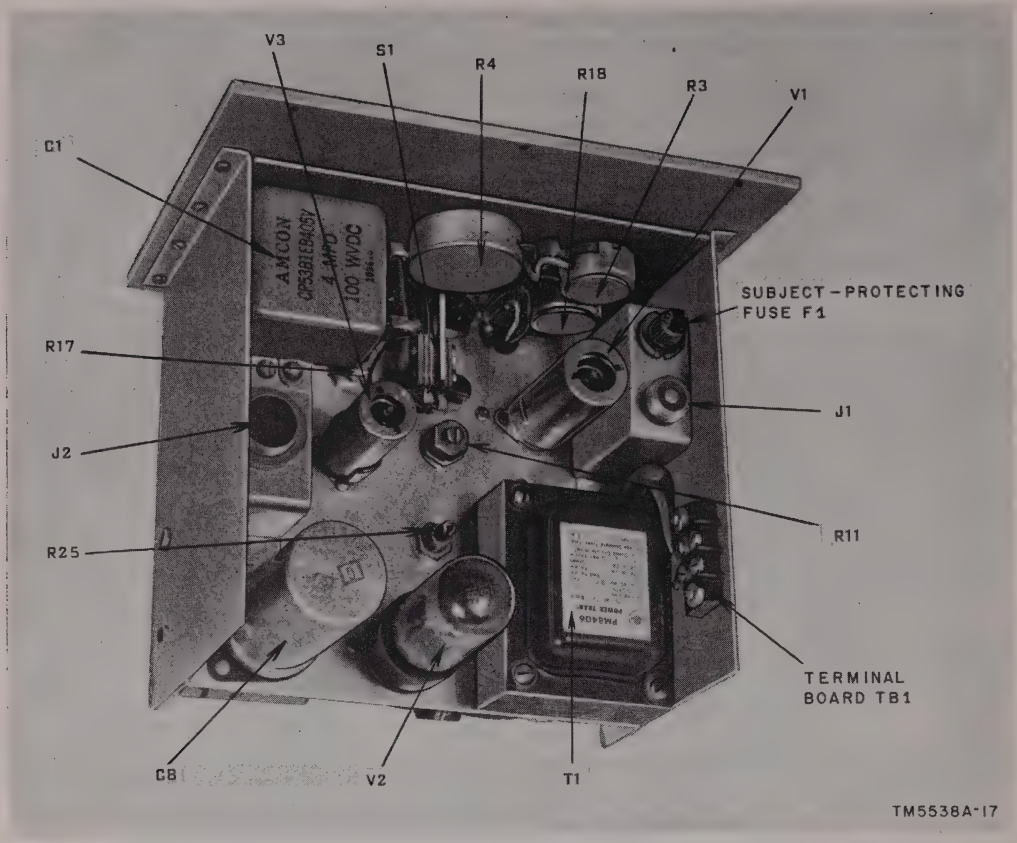



*Figure 21. Gsr amplifier top, parts location.*

25). Do not disassemble the galvanometer further, as special tools will be required for reassembly. Place the unit on a clean work bench which is covered with a clean sheet of paper. Visually inspect the coil leads for good contact and free movement. If necessary, resolder the lead wires carefuly with rosin core solder only. If the coil is still open or grounded, replace the entire unit.

*b.* If the coil circuit continuity has been restored by resoldering loose internal connection or replacing lead wires, check to see that the coil between pole pieces turn freely without binding. Realine the bearings carefully if alinement is necessary. Check the bearings for small play to insure free movement of the coil. If the coil is tight or nearly so, replace the entire unit.

*c.* Remove all metallic particles that may cling to the pole pieces with a wire or by a low-pressure air gun. First blow off any internal collection of oil or water to prevent damage to galvanometer coil system.

*Note.* An air blower may be used or any other device that furnishes a stream of low-pressure air to prevent damage to the delicate structure of the galvanometer coil system.

*d.* If the checks reveal that repairs are not possible at this level, replace the entire galvanometer-recorder unit.

***Caution:*** Do not disassemble the galvanometer-recorder beyond the removal of the side plate opposite the one shown in figure 25.

*e.* Check the performance of the galvanometer-recorder unit after the repairs have been com-

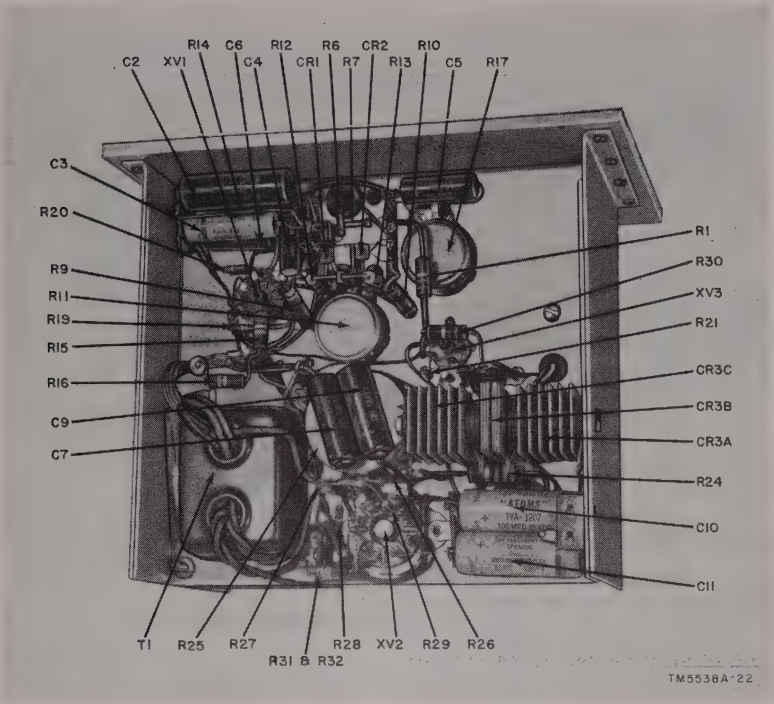



*Figure 22. Gsr amplifier bottom, parts location.*

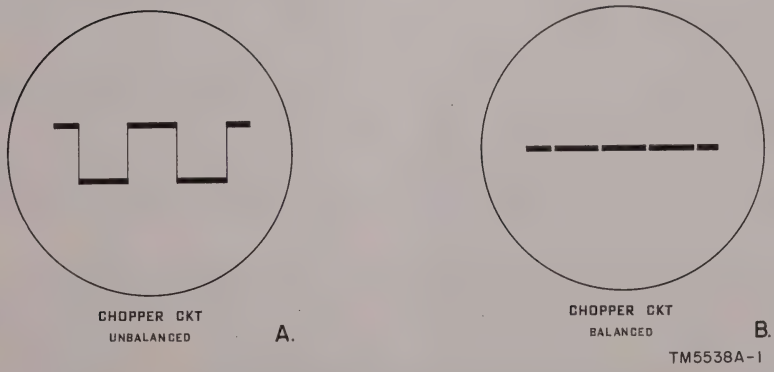
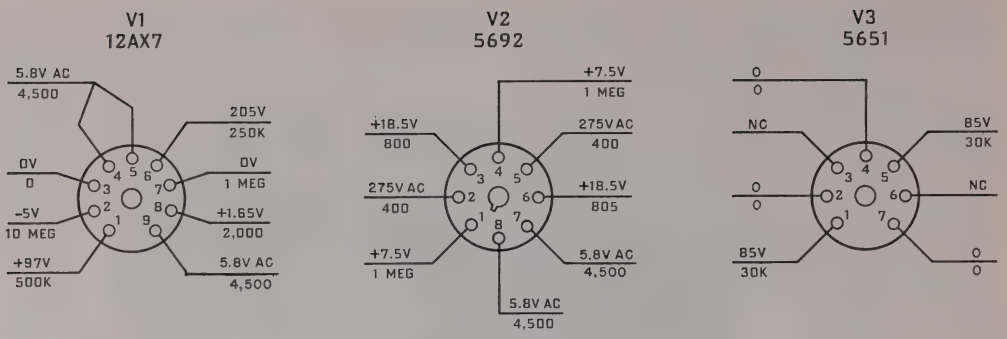



*Figure 23. Chopper-converter wave forms.*




NOTES:

1. ALL MEASUREMENTS TAKEN AFTER BALANCING-IN PROCEDURE AGAINST CHECKING FIXTURE.
2. VOLTAGES MEASURED BETWEEN TUBE PIN AND GROUND.
3. MEASUREMENTS TAKEN WITH VTVM.
4. RES READING BELOW LINE; VOLT READING ABOVE.

TM5538A-5

*Figure 24. Voltage and resistance measurement chart.*

pleted and if no defects are noted, remount it in the instrument frame.

## 65. Gsr Pen Travel Adjustment

The travel of the gsr pen must stop approximately ¼ inch from the line of chart paper perforations. If adjustments are required, see figure 25. Readjust by loosening the travel limiting screws. Shift the stopping brackets of the pen cradle and tighten the screws. Check the arc of pen travel. Repeat the procedure, if necessary, until the proper adjustment is made.

## 66. Final Testing of Gsr Section

Use the checking fixture for final checking the gsr section (par. 63*b*).

*a.* Set the SENSITIVITY control at HIGH, the zero-centering switch at MANUAL ZERO, and balance the CENTERING controls against the checking fixture resistances so that the gsr pen tracks the center line of the chart paper. Move the switch button to short out the 1,000-ohm resistor. The pen should move up on the chart paper approximately 1 inch from the base line to indicate correct operation of the gsr section.

*b.* The deviation of the sensitivity response of the gsr pen may be adjusted by screwdriver control R17 (fig. 28). This sensitivity adjustment will stay the same over entire range of input bridge limits. It may have to be reset after considerable aging or replacement of voltage amplifier tube V1.

## 67. Repair of Paper-Chart Mechanism

*a.* Failure of the chart-drive unit may be caused by a defective motor, tight gear bearings, tight roller shaft bearings, dirt between the gears, or twisted mounting plates. Remove the unit from the instrument frame by removing the top mounting screws, lifting it free, and then disconnecting the power line screw connector P5 (fig. 18).

*b.* If the chart-drive motor is defective, replace it by first removing the driving pinion held to the shaft by a pin. Transfer this pinion to the new motor.

*c.* Tight gear or roller shaft bearings can be reamed to give enough shaft clearance for easy running fit.

*d.* Remove the dirt lodged in the gear teeth with a stiff brush and apply grease (par. 39).

*e.* If the mounting plates are forced out of parallel alinement by warping of the enveloping case, build up or readjust the mounting members, where necessary, to clear this type of trouble.

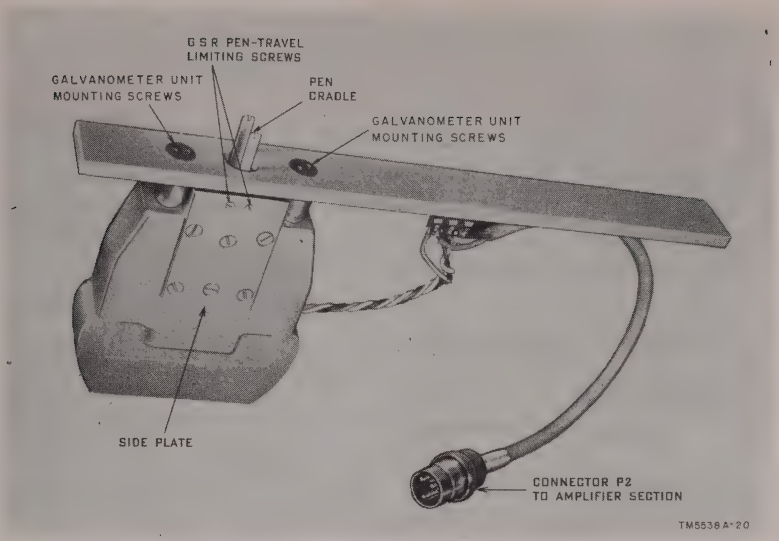



*Figure 25. Galvanometer-recorder panel, bottom view.*

# CHAPTER 7
# SHIPMENT, LIMITED STORAGE, AND DEMOLITION

## Section I. DISASSEMBLY AND REPACKAGING

### 68. Disassembly

The following instructions are recommended as a guide for preparing the lie detector for either transportation or storage:

*a.* Turn off the lie detector (par. 29*a* through *h*).

*b.* Remove the pneumograph, cardiograph, and finger electrode assemblies from the subject (fig. 1).

*c.* Remove the following connecting cables (fig. 1) from the equipment:

(1) Pneumograph rubber tubing.
(2) Cardiograph rubber tubing.
(3) Finger electrode wires.
(4) Ac power line cord.
(5) Hand-pump bulb rubber tubing (fig. 2).

*d.* Clean the equipment (par. 30).

*e.* Remove and store the pens in the pen retainer and checking fixture (fig. 4).

***Caution:*** Be careful when handling the pens as they are delicate instruments and can be easily damaged.

*f.* Remove the inkwell (fig. 8) and the chart paper roll (fig. 3).

*g.* Repack the equipment as instructed in paragraph 70.

### 69. Field Repackaging Data, Materials Required

The following chart lists the estimated amount of materials required to prepare the lie detector for shipment or storage:

| Materials | Amount |
|---|---|
| Water-vaporproof barrier | 14 sq ft |
| Flexible, corrugated paper | 10 sq ft |
| Gummed paper tape | 8 ft |
| Water-resistant, pressure-sensitive adhesive tape | 8 ft |
| Single- or double-faced corrugated fiberboard | 30 sq ft |
| Activated desiccant | 6 bags |
| Fiberboard box | 2 ea |
| Wood-cleated plywood nailed or wire-bound wooden box | 1 ea |
| Flat steel strapping | 14 ft |

### 70. Repackaging Lie Detector

Check the equipment for completeness (par. 12*b*) before proceeding with the repackaging as instructed below:

*a. Technical Manuals.* Wrap the manuals in the water-vaporproof barrier material. Seal all the seams and folds with the water-resistant, pressure-sensitive adhesive tape.

*b. Recording Pens.* Cushion each pen by wrapping them individually with the flexible, corrugated paper. After wrapping, place them in the pen racks provided in the pen retainer and checking fixture and place and secure the lid over the pens.

*c. Accessories.* Package each accessory by wrapping the flexible, corrugated paper around them and secure the cushioning with the gummed paper tape.

*d. Spare Parts.* Package the spare parts as instructed in *c* above.

*e. Tubes.* Remove all tubes that are not securely clamped in place and wrap as instructed in *c* above.

*f. Lie Detector.*

(1) Place the packaged items (*a* through *e* above) into the accessory compartment

and fill in all voids with flexible, corrugated paper to prevent movement. Secure the cushioning with gummed paper tape.

(2) Cushion the front panel and fill in the voids with flexible, corrugated paper and secure with paper gummed tape. Replace the top cover and secure the spring fastenings.

### 71. Repacking for Shipment or Limited Storage

The exact procedure in repacking for shipment or limited storage depends on the material available and the conditions under which the equipment is to be shipped or stored.

*a.* Place the packaged lie detector along with fully activated desiccant into the fiberboard box. Close the top of the box and seal it with gummed paper tape. Blunt all corners of the box with gummed paper tape.

*b.* Wrap the box with water-vaporproof barrier and heat seal the closure. If heat is not available, use gummed paper tape.

*c.* Place the water-vaporproofed case within another close-fitting fiberboard box and wrap and seal it as instructed in *a* and *b* above.

*d.* Place the lie detector as packaged above into a wooden cleated plywood nailed or wire-bound wooden box. Fill all voids with pads fabricated of single- or double-faced corrugated fiberboard material to prevent movement.

*e.* Place the package that contains the manuals between the packaged lie detector and the lid of the shipping box.

*f.* Nail the lid to the wooden box and bind the box with flat steel strapping.

## Section II. DEMOLITION OF MATERIEL TO PREVENT ENEMY USE

### 72. Authority for Demolition

Demolition of the lie detector will be accomplished upon the order of the commander. The destruction procedures outlined in paragraph 73 will be used to prevent further use of the equipment.

### 73. Methods of Destruction

Use any or all of the following methods to destroy the lie detector:

*a. Smash.* Smash the controls, ink bottle, tubes, switches, gage, all other accessory items, and spare parts; use sledges, axes, hatchets, pickaxes, hammers, or crowbars.

*b. Cut.* Cut the hoses, cables, and the power cord; use axes, hatchets, or machetes.

*c. Burn.* Burn the pneumograph, cuffs, hose cables, power cord, paper chart rolls, and the manuals; use gasoline, kerosene, oil, flame throwers, or incendiary grenades.

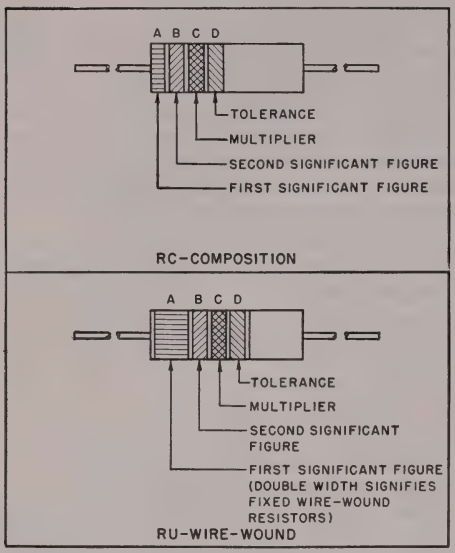
*d. Bend.* Bend the recording pens (and cut off the writing tips), inkwell, finger electrodes, inkwell filler, and pen starter; use wire cutters, pliers, and monkey wrenches.

*e. Explode.* If explosives are necessary, use firearms, grenades, or TNT.

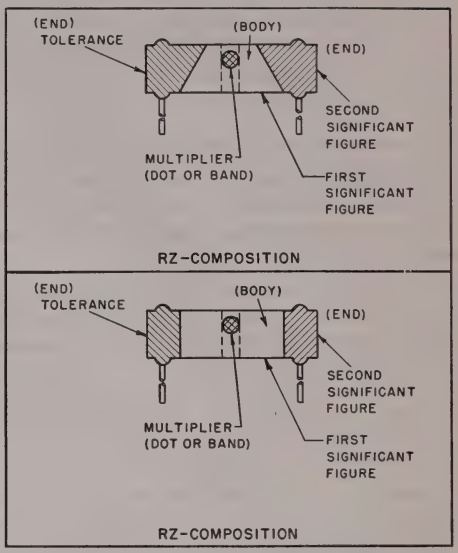
*f. Dispose.* Bury or scatter the destroyed parts in slit trenches, fox holes, or throw them into streams.

## RESISTOR COLOR CODE MARKING
## (MIL-STD RESISTORS)

### AXIAL-LEAD RESISTORS (INSULATED)




### RADIAL-LEAD RESISTORS (UNINSULATED)




## RESISTOR COLOR CODE

| BAND A OR BODY* | | BAND B OR END* | | BAND C OR DOT OR BAND* | | BAND D OR END* | |
|---|---|---|---|---|---|---|---|
| COLOR | FIRST SIGNIFICANT FIGURE | COLOR | SECOND SIGNIFICANT FIGURE | COLOR | MULTIPLIER | COLOR | RESISTANCE TOLERANCE (PERCENT) |
| BLACK | 0 | BLACK | 0 | BLACK | 1 | BODY | ±20 |
| BROWN | 1 | BROWN | 1 | BROWN | 10 | SILVER | ±10 |
| RED | 2 | RED | 2 | RED | 100 | GOLD | ±5 |
| ORANGE | 3 | ORANGE | 3 | ORANGE | 1,000 | | |
| YELLOW | 4 | YELLOW | 4 | YELLOW | 10,000 | | |
| GREEN | 5 | GREEN | 5 | GREEN | 100,000 | | |
| BLUE | 6 | BLUE | 6 | BLUE | 1,000,000 | | |
| PURPLE (VIOLET) | 7 | PURPLE (VIOLET) | 7 | | | | |
| GRAY | 8 | GRAY | 8 | GOLD | 0.1 | | |
| WHITE | 9 | WHITE | 9 | SILVER | 0.01 | | |

*FOR WIRE-WOUND-TYPE RESISTORS, BAND A SHALL BE DOUBLE-WIDTH. WHEN BODY COLOR IS THE SAME AS THE DOT (OR BAND) OR END COLOR, THE COLORS ARE DIFFERENTIATED BY SHADE, GLOSS, OR OTHER MEANS.

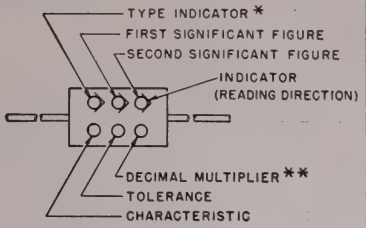
EXAMPLES (BAND MARKING):
10 OHMS ±20 PERCENT: BROWN BAND A; BLACK BAND B; BLACK BAND C; NO BAND D.
4.7 OHMS ±5 PERCENT: YELLOW BAND A; PURPLE BAND B; GOLD BAND C; GOLD BAND D.

EXAMPLES (BODY MARKING):
10 OHMS ±20 PERCENT: BROWN BODY; BLACK END; BLACK DOT OR BAND; BODY COLOR ON TOLERANCE END.
3,000 OHMS ±10 PERCENT: ORANGE BODY; BLACK END; RED DOT OR BAND; SILVER END.

STD-RI

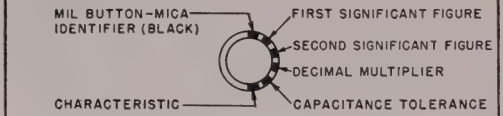
*Figure 26. MIL-STD resistor color codes.*

## CAPACITOR COLOR CODE MARKING
## (MIL-STD CAPACITORS)

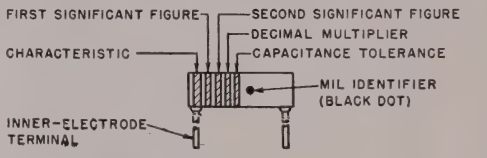


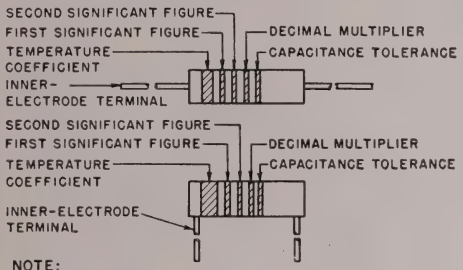

* BLACK DOT: MICA DIELECTRIC
SILVER DOT: PAPER DIELECTRIC
** INDICATES NUMBER OF ZEROS ON PAPER TYPE.

MICA (CM) AND PAPER (CN)



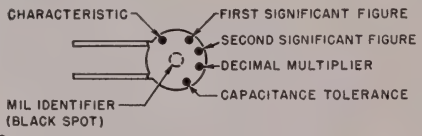

BUTTON-MICA (CB)




NOTE:
SPOTS MAY BE USED INSTEAD OF BANDS; TEMPERATURE COEFFICIENT MARKING IS LARGER.

CERAMIC-TEMPERATURE COMPENSATING (CC)




NOTES:
1. SPOTS MAY BE USED ON TUBULAR CAPACITORS; CHARACTERISTIC SPOT IS LARGER AND MIL IDENTIFIER IS ON SIDE DIAMETRICALLY OPPOSITE COLOR SPOTS.
2. MIL IDENTIFIER OF DISK TYPE IS ON REVERSE SIDE; CHARACTERISTIC SPOT IS LARGER OR SPACE BETWEEN CHARACTERISTIC AND TOLERANCE SPOTS IS THREE TIMES SPACE BETWEEN ADJACENT SPOTS.
3. TOLERANCE: YELLOW, +100%, -20%.

CERAMIC-GENERAL PURPOSE (CK)

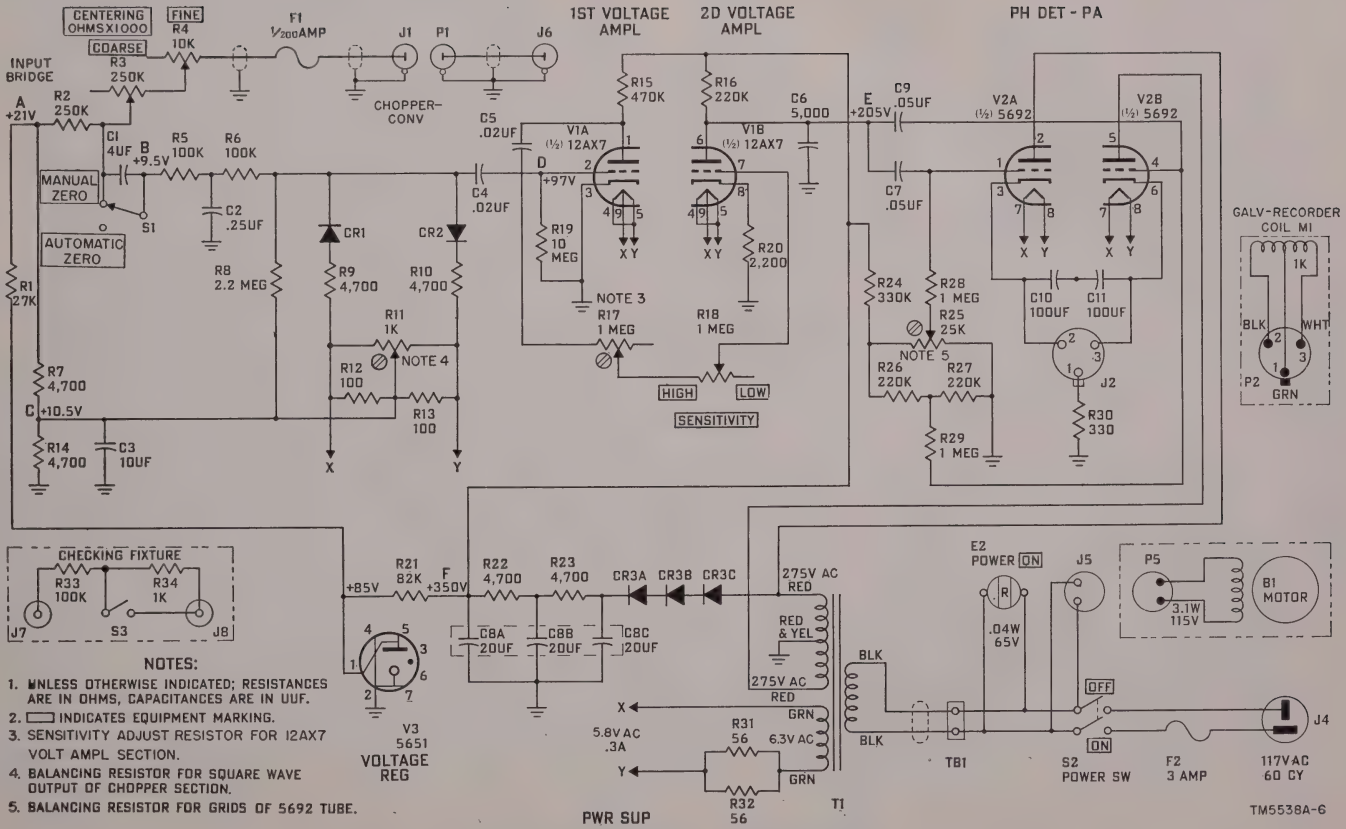
## CAPACITOR COLOR CODE

| COLOR | SIG FIG. | MULTIPLIER | | CHARACTERISTIC[1] | | | | TOLERANCE[2] | | | | | TEMPERATURE COEFFICIENT (UUF/UF/°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | DECIMAL | NUMBER OF ZEROS | CM | CN | CB | CK | CM | CN | CB | CC | | |
| | | | | | | | | | | | OVER 10UUF | 10UUF OR LESS | CC |
| BLACK | 0 | 1 | NONE | | A | | | 20 | 20 | 20 | 20 | 2 | ZERO |
| BROWN | 1 | 10 | 1 | B | E | B | W | | | | 1 | | -30 |
| RED | 2 | 100 | 2 | C | H | | X | 2 | | 2 | 2 | | -80 |
| ORANGE | 3 | 1,000 | 3 | D | J | D | | | 30 | | | | -150 |
| YELLOW | 4 | 10,000 | 4 | E | P | | | | | | | | -220 |
| GREEN | 5 | | 5 | F | R | | | | | | 5 | 0.5 | -330 |
| BLUE | 6 | | 6 | | S | | | | | | | | -470 |
| PURPLE (VIOLET) | 7 | | 7 | | T | W | | | | | | | -750 |
| GRAY | 8 | | 8 | | | X | | | | | | 0.25 | +30 |
| WHITE | 9 | | 9 | | | | | | | | 10 | 1 | -330(±500)[3] |
| GOLD | | 0.1 | | | | | | 5 | | 5 | | | +100 |
| SILVER | | 0.01 | | | | | | 10 | 10 | 10 | | | |

1. LETTERS ARE IN TYPE DESIGNATIONS GIVEN IN MIL-C SPECIFICATIONS.
2. IN PERCENT, EXCEPT IN UUF FOR CC-TYPE CAPACITORS OF 10 UUF OR LESS.
3. INTENDED FOR USE IN CIRCUITS NOT REQUIRING COMPENSATION.

STD-CI

*Figure 27. MIL-STD capacitor color codes.*




NOTES:

1. UNLESS OTHERWISE INDICATED; RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN UUF.
2. ▭ INDICATES EQUIPMENT MARKING.
3. SENSITIVITY ADJUST RESISTOR FOR 12AX7 VOLT AMPL SECTION.
4. BALANCING RESISTOR FOR SQUARE WAVE OUTPUT OF CHOPPER SECTION.
5. BALANCING RESISTOR FOR GRIDS OF 5692 TUBE.

*Figure 28. Gsr amplifier, main schematic diagram.*

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[AG 413.6 (20 Mar 57)]

By Order of *Wilber M. Brucker*, Secretary of the Army:

MAXWELL D. TAYLOR,
*General, United States Army,*
*Chief of Staff.*

Official:

HERBERT M. JONES,
*Major General, United States Army,*
*The Adjutant General.*

Distribution:

*Active Army:*

CNGB
ASA
Tec Svc, DA
Tec Svc Bd
Hq CONARC
CONARC Bd
CONARC Bd Test Sec
Army AA Comd
OS Maj Comd
OS Base Comd
Log Comd
MDW
Armies
Corps
Div
Ft & Cp
Sp Wpn Comd
Army Cml Cen
Gen & Br Svc Sch
Gen Depots
Sig Sec, Gen Depots
Sig Depots
WRAMC
US Army Tng Cen
AMS
POE (OS)
Trans Terminal Comd
Army Terminals
OS Sup Agencies
Army Elct PG
Sig Fld Maint Shops
Sig Lab
ACS
Mil Dist
JBUSMC
Units org under fol TOE:
11–7
11–16
11–57
11–127
11–128
11–500
11–557
11–587
11–592
11–597
19–500 (AA–AE)

*NG:* State AG; units—same as Active Army.

*USAR:* None.

For explanation of abbreviations used, see SR 320–50–1.

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